INSTRUCTIONS

FOR THE USE OF

ESTERLINE-ANGUS MODEL A. W.

GRAPHIC INSTRUMENTS

INCLUDING CONNECTION DIAGRAMS
AND INSTRUMENT DATA SHEET

THE ESTERLINE-ANGUS COMPANY, INC.
INDIANAPOLIS, INDIANA, U. S. A.

SERIAL NUMBER [redacted]

THE ESTERLINE-ANGUS COMPANY, INC.

P. O. BOX 596 • INDIANAPOLIS 6, INDIANA, U. S. A.

RECORDER DATA SHEET for Model AW A.C. VOLTMETER

Sold to Boeing Airplane Company, Seattle, Washington

Pur. Order No. 335258-07 MO No. SO No. G-1889

For use by Same

CASE Portable For panel. Lamp

Other Case Features

MEASURING ELEMENT A.C. Voltmeter NP No. 8912 ME No. 342-B

Scale 0-150 Volts Sc. No. V-15-150 **CHART No.** 1316-X

Calibrated for Use With Damping No. 3.0 A

Calibration or Rating: Wire 2 Phase Single Cycles 400 Pressure

Voltage 0-150/300 Volts (Max. Volts)

Current (Max. Amps.)

Watts

Millivolts at amp. ( ) at 30° C. at Shunt End of Leads.

Mult. Box Attached No. 8850 Volts 150/300 Volts Mult. NP No.

Mult. Box No. Volts Mult. NP No.

Range 150V Total Ohms: A 1691 B Mult. Ohms: A 575 B MV at Meter: A

Range 300V Total Ohms: A 2524 B Mult. Ohms: A 1408 B MV at Meter: B

Range Total Ohms: A B Mult. Ohms: A B Comp. Ohms: A 1003

Range Total Ohms: A B Mult. Ohms: A B Comp. Ohms: B

Range TC.

Armature Ohms: A 113 B Parallel Cir. Ohms Meter Ohms FS Grams Torque .85

LEADS—Current: No. , ft. long, No. wire. Potential: 2 No 8935 , 5 ft. long, No. 14 wire.

ID No. D-844 Connection Diagrams S-2822, D-940 Lead ohms Lead MV

Other Measuring Element Features

CHART DRIVE: Type No. 20, Rapid Feed Synchronous with Mag. Shift & Quick Trip

Feeds: In. per Hr. 3/4-1½-3-6-12 In. per Min 3/4-1½-3-6 In. per Sec. 3/4-1½-3

FS No. 79-F Internal Motor: Volts 115 Cycles 60

Int. Trip Coil: No. 10150-B Volts 115 Cycles 60 Ohms 35 Series Ohms

External Motor: FS No. 11-S Volts 115 Cycles 60 No. 648X391 Rheo.

Ext. Trip Coil: No. 10150-B Volts 115 Cycles 60 Ohms 35 Series Ohms

Other Chart Drive Features Clock switch per S-2903

ATTACHMENTS

Right Hand Chron. Pen: No. Volts Cycles Ohms Series Ohms

Left Hand Chron. Pen: No. Volts Cycles Ohms Series Ohms

INSULATION TESTS (AC Volts): Meter Element 5000 Internal Motor 1500 Ext. Motor 900

Lamp Circuit Chronograph Pens Trip Coils 1500 Aux. Transf.

AUXILIARY APPARATUS FURNISHED BY ESTERLINE-ANGUS

POT. TRANSF: Mfr. Model Volts: Pri. Sec. Cycles

CUR. TRANSF: Mfr. Model Amperes: Pri. Sec. Cycles

Phase shifting Network: No. Volts Cycles Volts Cycles

SHUNTS: Type Rated amperes MV Amp. at Rated MV

DS by JEH DS check by Calib. by Heber

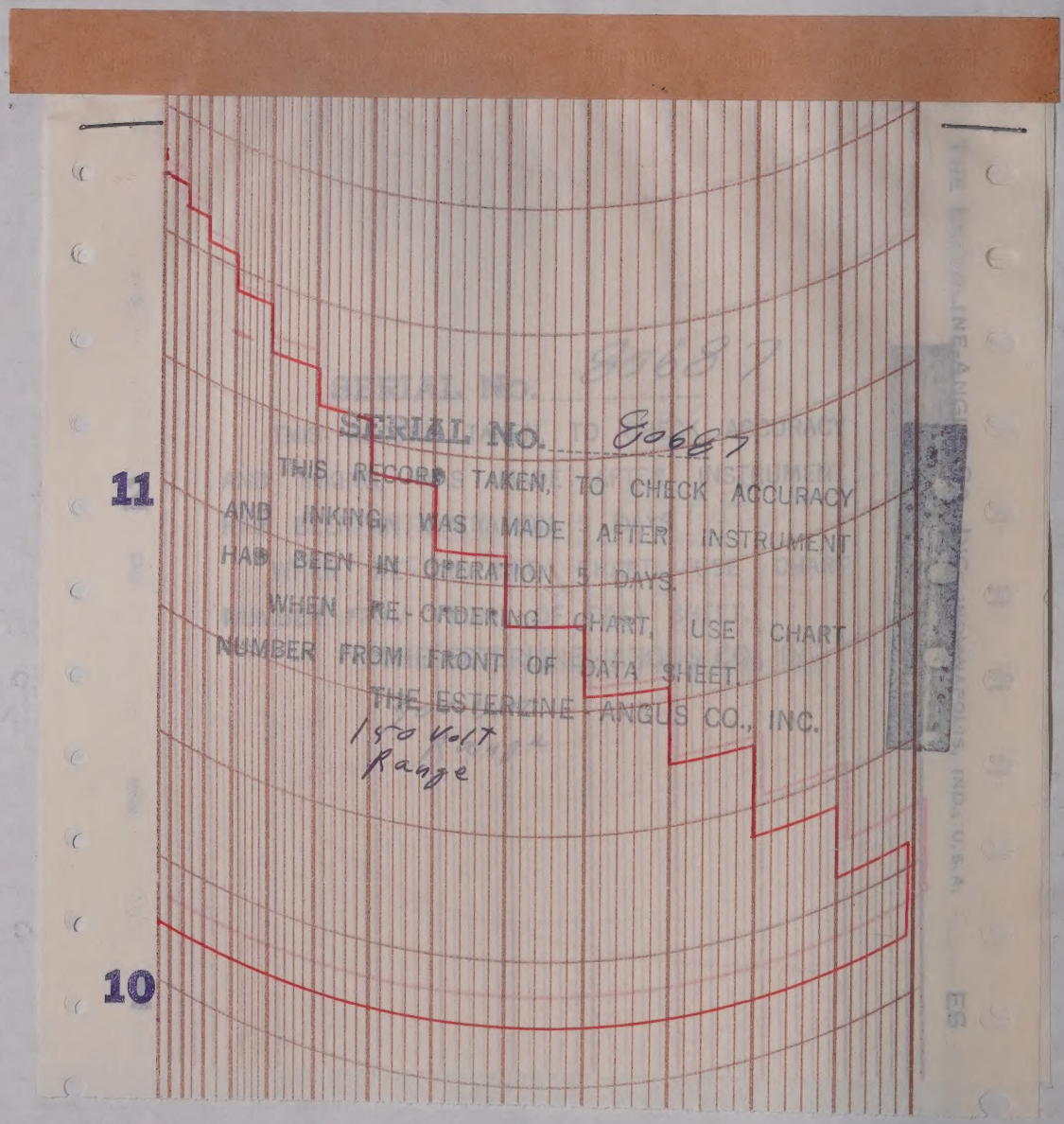
Inspections: 1st Final Jones Date 4-11-49

Meter card entry

SERIAL No. ~~8 0 6 8 7~~ AW

Mention this number in correspondence.

FORM 281-25M-6-47


SERIAL NO. E0667
THIS RECORD TAKEN, TO CHECK ACCURACY
AND INKING, WAS MADE AFTER INSTRUMENT
HAD BEEN IN OPERATION 5 DAYS.
WHEN RE-ORDERING CHART, USE CHART
NUMBER FROM FRONT OF DATA SHEET.
THE ESTERLINE-ANGUS CO., INC.
150 Volt
Range
11
10

GENERAL INSTRUCTIONS

FOR

ESTERLINE-ANGUS MODEL AW GRAPHIC INSTRUMENTS

These instructions are a guide to the correct operation of Esterline-Angus graphic instruments. These instructions should be read by the person who uses or services the instruments, and should be kept in a convenient place for reference. Additional copies of this instruction book will be furnished on request.

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UNPACKING

Esterline-Angus instruments are carefully packed; carriers are responsible for damage in transit. If the packing case shows damage, make a notation to that effect on your express receipt or freight bill. If it is found that the shipment has been damaged, notify the carrier at once.

Included with each shipment will be found a packing list, showing every item in the shipment. Check off each item as the goods are unpacked, and if any item appears to be missing, go through the packing material carefully before it is thrown away. The missing articles may have been overlooked when the packing material was removed.

Each instrument is carefully inspected at the Esterline-Angus factory and then sealed before shipment. New instruments are shipped complete with necessary multiplier boxes and leads, one record chart, and a box of accessories containing one two-ounce bottle of red ink, one inkwell filler, one pen filler, and one spare glass pen. Two charts and two accessory boxes are furnished with twin instruments.

On an instrument which is to be permanently installed, it is advisable to leave the seal intact until the instrument is required for use.

INSTALLING

Front switchboard, wall, and flush instruments should be mounted LEVEL in a clean, light place, with the bottom of the instrument about four feet from the floor. The instrument should be mounted where it will not be subjected to vibration or extremes of temperature. If unusual steam, smoke, moisture, dust, or corrosive fumes are present, a protective cabinet should be built around the instrument. Drilling dimensions furnished by the factory should be followed when mounting instruments on panels. Front or flush switchboard instruments can be mounted either on slate or steel panels, the drilling dimensions being furnished for the kind of panel specified when the instrument was ordered. Front switchboard DC instruments are specially calibrated if they are to be mounted on a steel panel. A switchboard DC instrument, if calibrated for the customary insulating panel, will read low if

 80687

mounted on a steel panel.

Multipliers for front switchboard and wall type instruments are housed in separate boxes and marked with the instrument serial number. Multipliers for portable and flush instruments are attached directly to the instrument case. All separate multipliers must be mounted vertically. Never put a multiplier in a closed compartment or obstruct the flow of air through it.

Do not locate instruments close to bus bars or cables carrying large currents. This is especially important for DC wattmeters. Bus bars should be kept at least three feet from the meter case.

Switchboard type shunts must be mounted with the blades vertical to permit free circulation of air. Shunts should be mounted with at least three feet of unbroken bus bar extending from both ends. Never crowd a shunt into the bus structure between other shunts, or install it above another shunt.

The cases of portable, front switchboard, and wall type instruments have latches that can be sealed with standard meter seals or locked with a small padlock. Padlocks can be supplied by THE ESTERLINE-ANGUS COMPANY. All flush instruments have a lock built in the case door. Two keys are furnished with each instrument and these keys fit any flush case lock.

SETTING UP FOR USE

To place an instrument in service, break the seal and take off the front cover as follows: Open the latch on top of the case, swing the top of the cover open about six inches and slide the lower end toward the instrument case to disengage the hinges. Lay the cover aside until the instrument is charted and inked. Always keep the cover closed when the instrument is in use. Flush instruments have a door which should be unlocked and swung open for access to the mechanism.

To protect the instrument mechanism during shipment, a cardboard retainer is fitted over the drive roll and pen table and extends into the movement compartment where it engages the pen fork to prevent unnecessary swinging of the moving element. The pen element is carried by two ears on this cardboard cover. Remove the pen element and lay it aside. Pull out the cardboard according to the directions printed on it. The instrument is then ready for filling with ink and inserting the chart, as described later.

CONNECTING

Do not connect the instrument without first referring to the wiring diagrams in this book. A wrong hook-up may cause the instrument to read incorrectly or may cause permanent damage. All terminals are marked with an identifying letter or voltage. Positive instantaneous polarity is indicated by a prime mark (’). This mark appears both on the instrument terminals and on the connection diagrams.

Current leads are furnished with meters used with external shunts, and

are marked with the meter serial number. These meters are calibrated for the correct voltage drop AT THE SHUNT END OF THE LEADS furnished with them, and only these leads can be used. Other connections should be made with #14 wire or larger.

A set of leads is furnished with portable instruments. These leads have taper plugs on the instrument end and open spade terminals on the other end. Keep the plugs and terminals clean to insure good contact. All meter terminals for plug connections are threaded inside so the instrument can also be used with binding post connections. Binding posts can be obtained from THE ESTERLINE-ANGUS COMPANY by giving the serial number of the instrument. Do not use binding posts on any meter operated from shunts. For connections between meter and shunts, only the calibrated leads furnished with the meter may be used.

INSERTING THE CHART. See Illustration Sheets Nos. 539A-1&2.

Take out the reroll stick. Place the hole in the chart core over the buttons on the clock plate and supply roll bracket so that the chart roll is securely held yet free to revolve. The time figures on the chart must be at the left.

Unwind the end of the chart, cut or tear to a "V" shape and insert the end in the slot marked "Insert end of chart here". Push the chart until the end appears over the pen table. Pull the chart over the drive roll, engaging the chart perforations with the drive roll pins. Turn the knurled set wheel on the right hand end of the drive roll until sufficient chart is unwound to reach the reroll stick.

Before attaching the end of the chart to the reroll stick, see that the clip on the reroll disk is at the front. If it is not in this position, turn the disk forward until the clip stops at the front. (This is possible by virtue of a friction clutch in the reroll gear train.) Wrap two or three turns of chart around the reroll stick and replace the stick so that the chart paper is under the clip and the clip is over the flat place on the stick. Release the automatic reroll catch by turning the stick backwards slightly and then letting it turn slowly forward until the slack in the chart is taken up.

The reroll stick should turn freely and have a slight end play. If there are too many layers of chart under the clip, the reroll mechanism will bind. Set the chart to time by turning the set wheel until the writing pen indicates the correct time of day on the chart with reference to the time numbers printed along the left hand edge of the chart.

STARTING THE CLOCK

BE SURE THE CLOCK IS WOUND. Since various types of chart drives are supplied with Esterline-Angus instruments, a special instruction section concerning the chart drive will be found in this book. Read this section carefully before starting the clock.

INSPECTING THE RECORD

The chart can be pulled from the reroll to examine the record. The reroll operates like a window-shade. A sudden release of tension on the unrolled chart will lock the reroll, removing tension from the chart and allowing it to be examined at leisure. To rewind the chart, first pull it forward slightly, then let it wind slowly on the reroll stick. Any amount of chart can be pulled from the reroll without damaging the mechanism.

FEEDING CHART THROUGH BOTTOM OF CASE

On all instrument cases except the flush, provision is made for feeding the chart through a slot in the bottom of the case. To feed through instead of rerolling, remove the metal or rubber strip at the lower edge of the case cover. The end of the chart which hangs out of the case should be weighted with a paper clamp. Do not pull or jerk on the end of the chart or it may be thrown out of time.

REMOVING THE CHART

To remove a used chart from the meter, take out the rerolled chart with the reroll stick, and pull the stick out of the chart, using a twisting motion. The chart is then ready for inspection or filing. An Esterline-Angus Chart Inspector is a useful device for routine examination of record charts, and we suggest that it be purchased if a number of charts are to be studied.

CHART FEEDS

Unless otherwise specified, the standard chart feed is three inches per hour. Change gears to provide other chart feeds can be furnished, and will be found on studs at the bottom of the clock mounting plate. The following table shows the combinations of gears to obtain different chart feeds.

DRIVING GEAR No. of Teeth	DRIVEN GEAR No. of Teeth	CHART FEED, Inches Per Hour or Per Minute
18	72	3/4
30	60	1-1/2
45	45	3
60	30	6
72	18	12*

*The 12-inch per minute speed is available but not guaranteed.

To change the rate of chart feed, unscrew the change gear nuts; pull off the existing gears, slide on the desired gears and replace the nuts, being careful to engage the slots in the gear hubs with the keys on the gear shafts. Be sure that the change gear nuts are screwed up tight.

All record charts are six inches wide and are 103 feet long. Time figures are printed along the margin as follows: Charts for 3/4, 1½ and 3 inches per hour have time figures every three inches and are marked A.M. and P.M., using light faced type for A.M. and bold faced type for P.M. Charts for 6 inches per hour have time figures every six inches and also have the A.M. and P.M. designations. Charts for 12 inches per hour have time figures every six inches but do not have the A.M. and P.M. designations. This reduces the amount of chart paper lost when an E-feed chart is set to time.

A letter after the chart number indicates the feed. When ordering charts, be sure to specify the feed by adding the proper letter as follows: "A" for 3/4, "B" for 1½, "C" for 3, "D" for 6, "E" for 12 inches per hour, and "X" for no time markings. The "X" chart without time markings is useful on instruments operated only at minute speeds, or instruments where the chart is operated intermittently.

The minimum running time of charts on various feeds is as follows:

SPEED Inches Per Hour	Feet Used Per Day	Feet Used Per Week	*Minimum Running Time in Days
3/4	1½	10½	65-2/3
1½	3	21	32-1/3
3	6	42	15-2/3
6	12	84	7-1/3
12	24	168	3-2/3

SPEED Inches Per Minute	Feet Used Per Hour	Feet Used Per Day	Minimum Running Time in Hours
3/4	3-3/4	90	26-2/3
1½	7-1/2	180	13-1/3
3	15	360	6-2/3
6	30	720	3-1/3

*Actual running time may exceed the above minimum, depending upon starting time.

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FILLING WITH INK - See Illustration Sheet No. 539A-2.

First raise the scale plate and remove the pen element. Take out the inkwell by lifting the two handles and pulling it forward. Fill the inkwell through the pen opening, about three quarters full, using the ink and the inkwell filler furnished with the instrument. Replace the inkwell, being careful that it is under the spring clips which hold it in place.

Set the pen element in the pen fork properly, with the knife edges of

the element seated in the slots in the fork. The pen element is correctly balanced at the factory WHEN FULL OF INK, and will stay off the chart until the pen is filled. Fill the pen by means of the pen filler furnished with the meter, proceeding as follows: Compress bulb of the pen filler, lay flat side of soft rubber tip on the chart, insert glass pen into hole in rubber tip, and let filler suck ink through the pen until no bubbles are visible in the glass pen. Then remove pen element from filler and the pen should rest lightly on the chart.

Swing the pen across the chart several times. If it does not write properly, the pen probably has an air bubble in it, in which case the pen filling operation must be repeated. Lower the scale plate and make certain that the pen is properly seated in the pen fork and does not rub on the inkwell or scale plate. The indicating target above the glass pen must not touch the scale plate. If the pen is clean and properly primed with all bubbles removed, it will write for long periods without further attention.

CARE OF THE INKING SYSTEM

Use only Esterline-Angus graphic meter ink. It is made especially to satisfy the exacting requirements encountered in recording instruments. Keep the bottle tightly capped to prevent dirt from getting into the ink. Ink begins to thicken at low temperatures and heat must be provided in the instrument if the temperature stays below 20 degrees Fahrenheit.

The inking system should be inspected once a week. Fresh ink should be added to the inkwell; any dirt, lint or dried ink should be removed from the glass pen point, and some ink should be drawn through the pen element by means of the pen filler. Once a month, or oftener on "QUICK TRIP" meters, the inkwell and pen element should be emptied, washed and refilled.

To clean the inkwell, pry off the cover and wash the parts in water. See that the vent holes in the cover are open and that the cover is not bent when removing it. The pen element is best cleaned by blowing water through it with a pen filler. Intermittent writing, failure of the pen to write on sudden swings, a dark purplish color of the record line instead of the normal bright red, or a tendency of the ink to spread in the paper and produce a broad, fuzzy line, are all indications that the ink in the inkwell has thickened and oxidized and that the inking system should be serviced more often. Instruments that operate at high temperatures and instruments involving high chart speeds require special attention to the inking system.

Instruments are shipped with the pen elements properly balanced WHEN FULL OF INK and the balance adjustment should not be changed unless necessary. The pen balance should be such that when the chart is tapped lightly with one finger, the pen will bounce up and down on the chart. Too heavy a pen pressure on the chart will cause the pen to drag toward the center of the chart or will noticeably reduce the speed of response of the pen. Accordingly, if maximum response speed is desired, the pen pressure must be no greater than is necessary for satisfactory inking. Handle the pen element carefully; a

bent element will cause incorrect readings. The writing tip of the glass pen must be exactly 4-3/8 inches from the knife edge. An arc line is marked on the pen table, making it easy to check this length without removing the pen element from the instrument.

The glass writing pen is a taper fit in a metal pen tube and is easily removed by twisting it out. The pen is ground at the factory to give a suitable line for most requirements, but extra-fine points can be furnished. If a wider line is desirable, grind the point with a fine white Arkansas stone wet with water, being sure to grind the face of the point square. If a glass pen is broken off in the pen tube, it can be removed by running a fine wire clear through the broken pen and tube, tying a small knot in the wire, and then pulling the broken pen out with the wire. Sometimes it may be necessary to slightly heat the tube around the pen to get the pen loose. In replacing a glass pen, be sure it rests perpendicular to the chart, otherwise it will not write properly. It is convenient to have one or more extra pen elements on hand. These can be cleaned in the shop and changed in the field, without taking the meter out of service.

Do not spill ink on the instrument. Remove any spilled ink with a rag or blotter immediately. If any ink is accidentally spilled on the clothing, wash it out as soon as possible, using warm water and any good soap which will not injure the fabric. By persistant washing and scrubbing the ink spots can be completely removed. Ordinary soap and water will remove ink stains from the hands, but the sooner they are removed, the easier the job is accomplished.

TECHNICAL INFORMATION

Esterline-Angus graphic instruments are accompanied by a technical data sheet, giving information pertaining to the instrument. This data sheet is a part of the instruction book and should be kept for reference. Part of this information will also be found on the nameplate inside of the case at the bottom. On the back of the data sheet will be found an original record made by the instrument as it was checked at the factory.

SUPPLIES AND PARTS

To obtain the most benefit from the investment which instruments represent, they should be kept in continuous service. Portable instruments should be moved to another job as soon as one job is finished. If the purpose for which the instrument was originally purchased has been fulfilled, the instrument should be used elsewhere to keep it active and thus to distribute its cost over a greater number of jobs.

Although the ESTERLINE-ANGUS factory is prepared to ship charts and ink the same day the order is received, the user should forecast his need for these essential items so that his instrument need never be idle for want of supplies. Keep on hand at all times enough charts and ink to operate each meter for at least one month. By purchasing in larger quantities, worthwhile savings can be made on these items.

Record charts should be ordered by number. This number will be found on the right hand edge of the used chart. When charts of various ranges are available for use on the same meter, a list of such charts is included in this instruction book.

Esterline-Angus ink is supplied in two colors: Red and Green, and is put up in two-ounce and one-pint bottles. Red ink is standard and will be furnished unless otherwise specified.

When ordering parts for this recorder, always give the serial number. This number is stamped on the nameplate inside the meter case, also on the scale plate and on the chart drive name plate.

GUARANTEE

Esterline-Angus instruments are guaranteed to be free from defects due to faulty materials or workmanship. Any instrument proving defective within one year from date of shipment will be repaired or replaced free of charge when returned to our works prepaid, provided the instrument has not been tampered with or misused. We do not assume responsibility for repairs made outside our plant.

PACKING FOR SHIPMENT

If the instrument is to be returned to the factory for repairs, send for shipping instructions and at the same time state clearly the reason for return. If time does not permit this normal handling, the following procedure should be observed: Wash out inkwell and pen element, remove pen element from pen fork and tie it across top of scale plate. Remove studs from switchboard instruments. Protect glass front with a small board and wrap instrument in heavy paper to prevent excelsior from sifting into the mechanism.

BE SURE TO RETURN ANY SEPARATE MULTIPLIERS, AND BE SURE TO RETURN THE LEADS FOR DC WATTMETERS OR AMMETERS. We MUST have these items at the factory when the meter is to be repaired or recalibrated. Return the entire set of leads furnished with portable meters. If the meter being returned is a speed recorder, return the tachometer generator and any indicators used with it. If only the clock is in need of repair, it should be removed from the meter, eliminating the necessity of shipping the entire instrument.

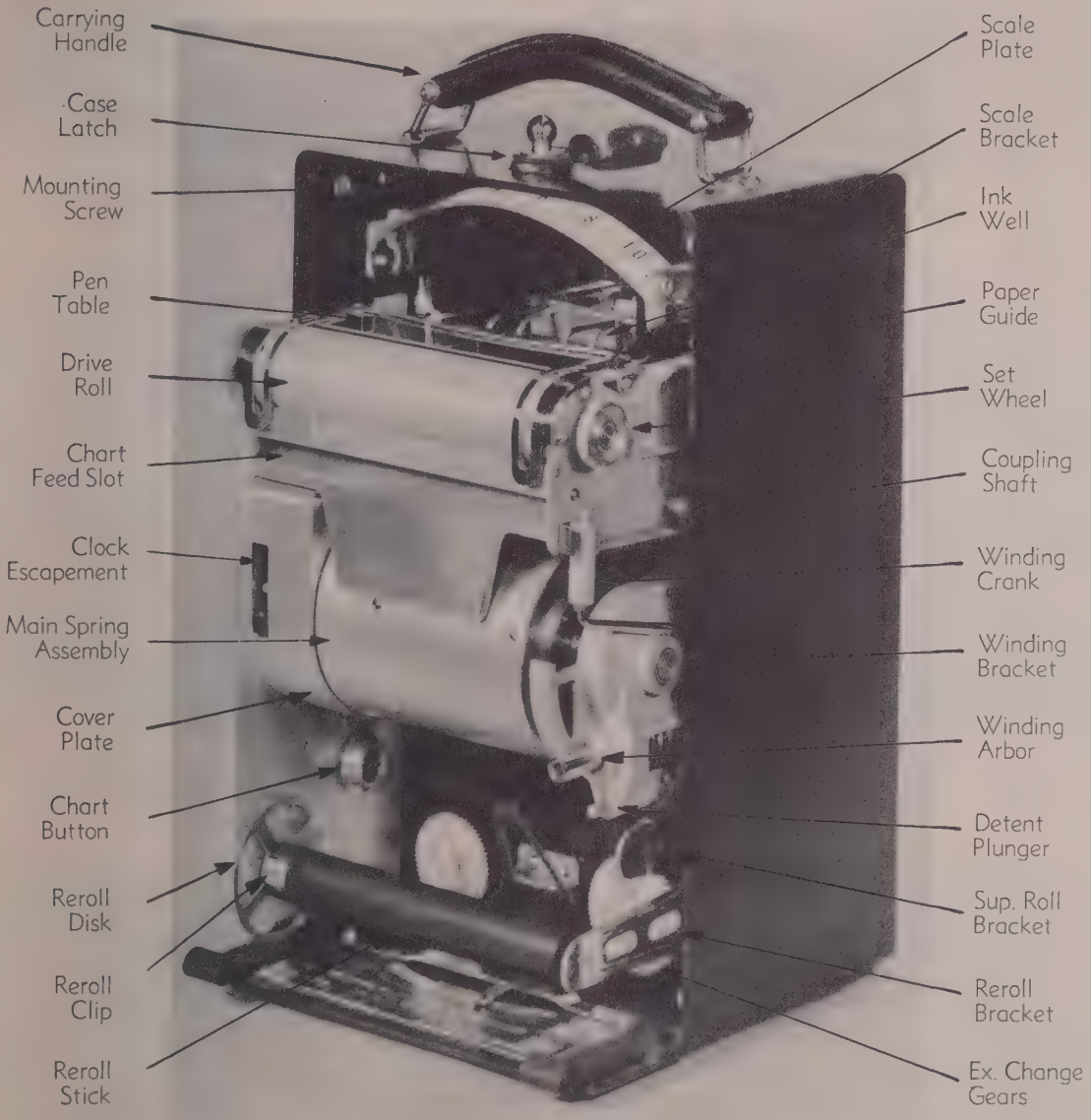
Use a strong, substantial packing box, large enough to permit at least eight inches of dry excelsior on all sides of the instrument. Ship by prepaid express and mark: "Electrical Instrument, Handle Carefully."

THE ESTERLINE-ANGUS COMPANY, INC.,
Indianapolis 6, Indiana.
U.S.A.

ESTERLINE-ANGUS GRAPHIC RECORDER

ILLUSTRATING

PORTABLE CASE AND SPRING CLOCK



THE ESTERLINE-ANGUS COMPANY, Inc.

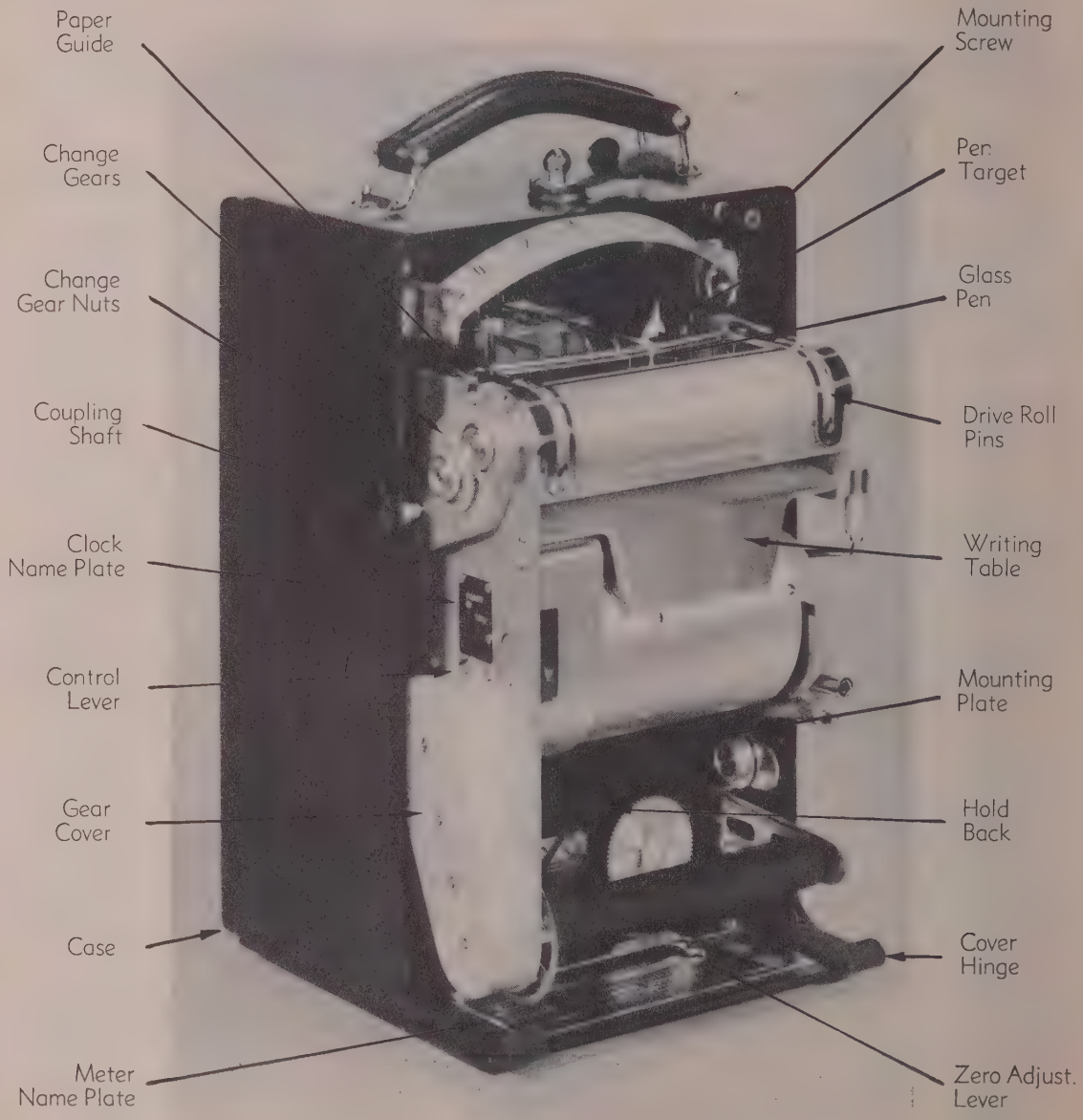
Indianapolis, Ind., U.S.A.

ESTERLINE-ANGUS GRAPHIC RECORDER

ILLUSTRATING

PORTABLE CASE AND SPRING CLOCK

Continued



THE ESTERLINE-ANGUS COMPANY, Inc.
Indianapolis, Ind., U.S.A.

THE ESTERLINE-ANGUS MODEL AW GRAPHIC METER

INSTRUCTIONS FOR PLACING IN SERVICE

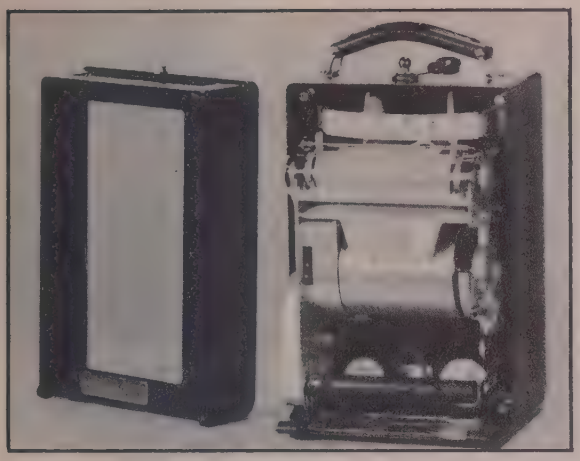


Fig. 1. OPENING METER. Break seal, open latch and remove cover. Take out "tie-up" card.

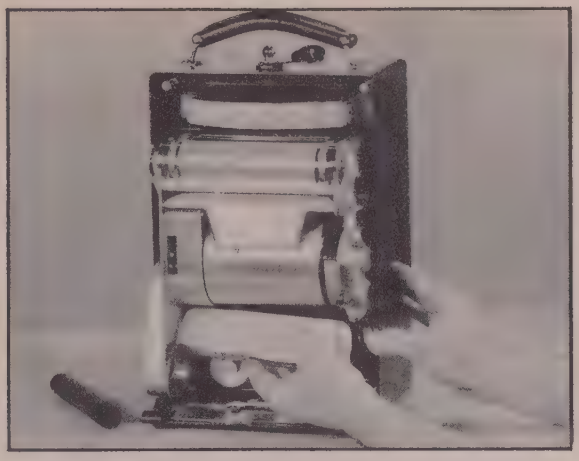


Fig. 2. INSERTING NEW CHART. Remove reroll stick. Insert chart in meter with time numbers at left.

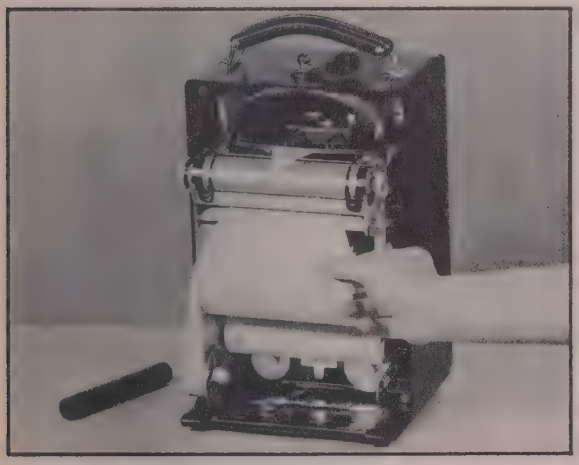


Fig. 3. THREADING CHART. Tear or cut end of chart "V" shaped and insert in feed slot. Push chart until end comes out over pen table.

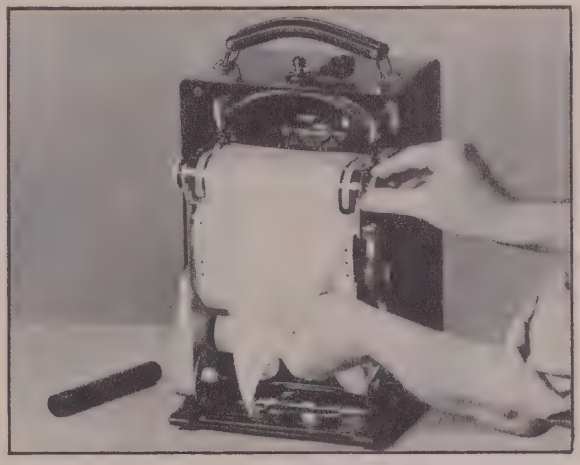


Fig. 4. THREADING CHART CONTINUED. Pull on end of chart and turn set wheel, engaging pins in perforations at edges of chart

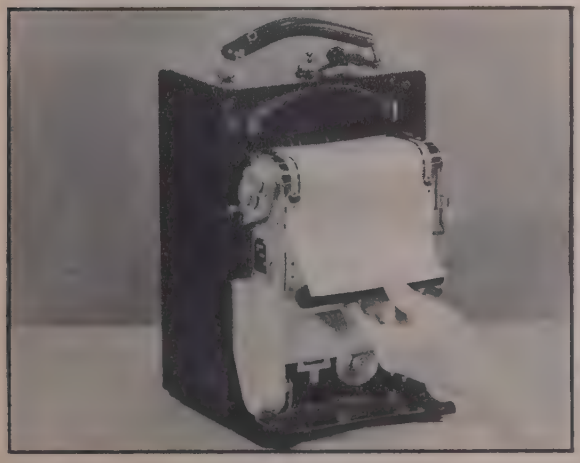


Fig. 5. ATTACHING TO REROLL. Tear or cut chart square across, ready to wrap on reroll stick.

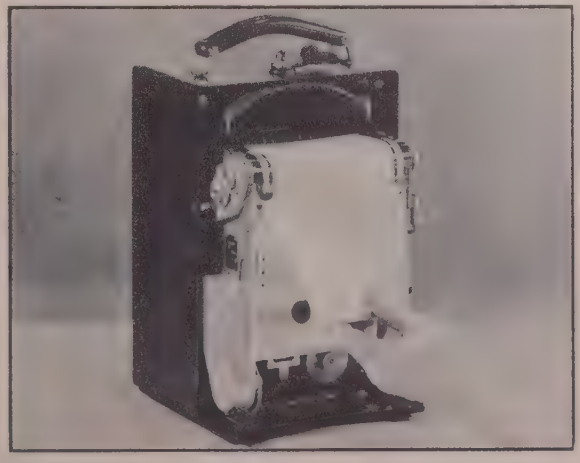


Fig. 6. ATTACHING TO REROLL CONTINUED Wrap two turns of chart around reroll stick and even chart with ends of stick

THE ESTERLINE-ANGUS MODEL AW GRAPHIC METER

INSTRUCTIONS FOR PLACING IN SERVICE—Continued

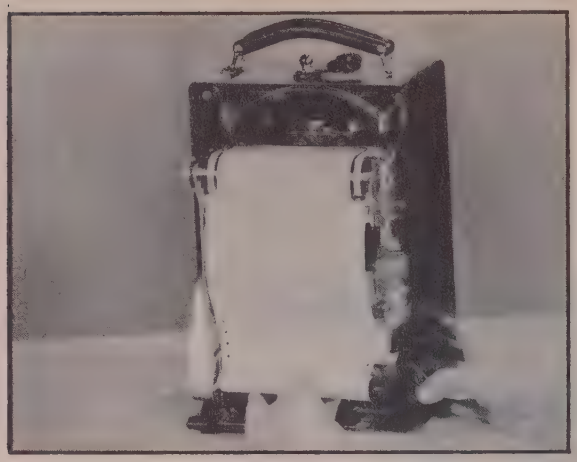


Fig. 7. ATTACHING TO REROLL CONTINUED. Insert reroll stick, keeping flat section under clip. Release reroll by backing slightly.

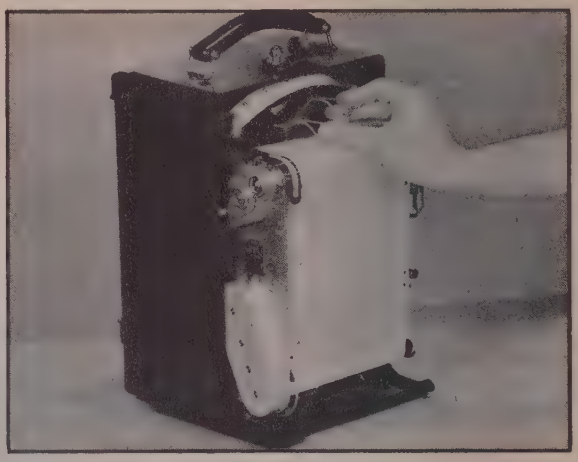


Fig. 8. REMOVING INK WELL. Raise scale plate. Grasp ink well handles and pull forward, lifting ink well out of meter.

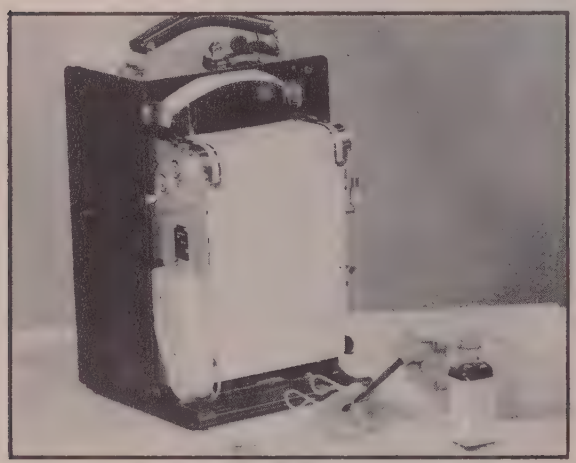


Fig. 9. FILLING INK WELL. Using ink well filler and ink from accessory box, fill ink well to 1/8 inch of top. Replace ink well in meter.

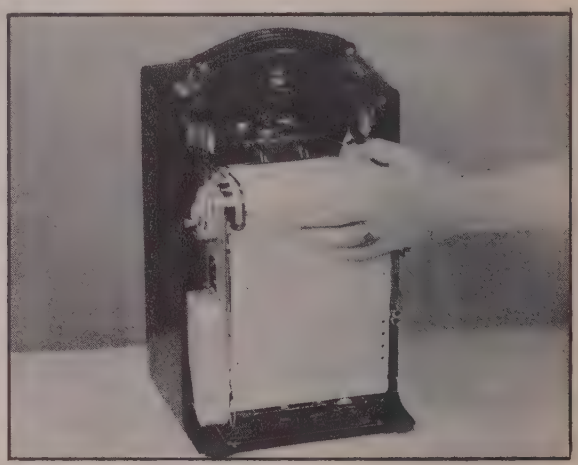


Fig. 10. INSERTING PEN ELEMENT. Place pen element in pen fork, being sure it is properly seated. Pen will remain off of chart until filled with ink.

Fig. 11. FILLING PEN. Using pen filler from accessory box, suck pen element full of ink. Watch glass pen to see that all air bubbles are removed.

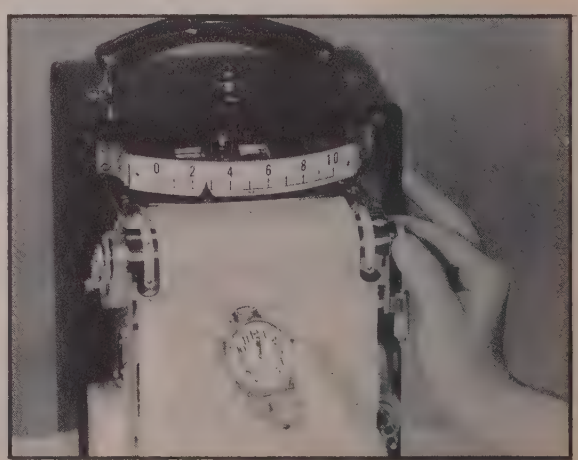


Fig. 12. SETTING TO TIME. Swing pen across chart to see that it inks properly. Turn set wheel until correct time of day appears under pen tip.

INSTRUCTIONS FOR THE OPERATION

OF

ESTERLINE-ANGUS SYNCHRONOUS MOTOR CHART DRIVES

MODEL AW

SEE ILLUSTRATION SHEETS NOS. 539A-1 & 2

GENERAL

The synchronous motor chart drive is similar to and interchangeable with the spring driven unit shown in the illustrations. The power is furnished by a specially built, self starting, single phase, synchronous motor which takes the place of the mainspring assembly. Motors can be furnished for operation on 60, 50, or 25 cycles per second and 115, 230, or 460 volt circuits. The motor requires 5 to 6 watts for operation. Before connecting the motor, be sure that the voltage and frequency of the circuit corresponds to the marking on the motor terminals which are brought out at the terminal board on the back of the instrument. A nameplate on the motor identifies the model and gives the voltage and frequency on which the motor is to operate.

WINDING THE REROLL

The reroll is driven by a spring and is wound by inserting the crank in the winding arbor and turning it in a clock-wise direction. When not in use, the crank is held in a spring clip on the side of the drive roll bracket. When the spring is fully wound, a friction clutch will slip and prevent breaking the reroll spring by over-winding. One winding is sufficient to reroll one complete chart and requires approximately 75 turns of the crank.

STARTING THE CHART DRIVE

The chart will start as soon as the current is turned on. If it is desired to stop the chart a switch should be provided in the motor wiring or the leads must be disconnected. A switch can be provided on the chart drive if ordered.

CHARTS

Keep the charts dry. Use only dry, clean charts in this instrument and keep the front cover or door closed to protect the mechanism and charts from moisture and dirt. Use only genuine Esterline-Angus record charts.

CHART FEEDS

The most commonly used chart feed is three inches per hour. Change gears to provide other chart feeds can be furnished, and will be found on studs at the bottom of the clock mounting plate. The following table shows the combination of gears to obtain different chart feeds.

DRIVING GEAR No. of Teeth	DRIVEN GEAR No. of Teeth	CHART FEED, Inches Per Hour or Per Minute
18	72	3/4
30	60	1 1/2
45	45	3
60	30	6
72	18	12*

*The 12-inch per minute speed is available but not guaranteed.

To change the rate of chart feed, unscrew the change gear nuts, pull off the existing gears, slide on the desired gears and replace the nuts, being careful to engage the slots in the gear hubs with the keys on the gear shafts. Be sure that the change gear nuts are screwed up tightly.

RAPID CHART FEEDS

Chart feeds in inches per minute, corresponding to the standard hour feeds, can be obtained with rapid feed chart drives. To change the chart from a given rate in inches per hour to the same rate in inches per minute, move the control lever to the "Rapid Feed" position.

INSERTING THE CHART See Illustration Sheet No. 539A-2

Take out the reroll stick. Place the hole in the chart core over the buttons on the clock plate and supply roll bracket so that the chart roll is securely held yet free to revolve. The time figures on the chart must be at the left.

Unwind the end of the chart, cut or tear to a "V" shape and insert the end in the slot beneath the drive roll market "Insert end of chart here". Push the chart until the end appears over the pen table.

Pull the chart over the drive roll, engaging the chart perforations with the drive roll pins. Turn the knurled set wheel on the right hand end of the drive roll until sufficient chart is unwound to reach the reroll stick

Before attaching the end of the chart to the reroll stick, see that the clip on the reroll disc is at the front. If it is not in this position, turn the disc forward until the clip stops at the front. (This is possible by virtue of a friction clutch in the reroll gear train.) Wrap two or three turns of chart around the reroll stick and replace the stick so the chart paper is under the clip and the clip is over the flat place on the stick. Release the automatic reroll catch by turning the stick backwards slightly and then letting it turn slowly forward until the slack in the chart is taken up.

The reroll stick should turn freely and have a slight end play. If there are too many layers of chart under the clip, the reroll mechanism will bind. Set the chart to time by turning the set wheel until the writing pen indicates the correct time of day on the chart with reference to the time numbers printed along the left hand edge of the chart.

INSPECTING THE RECORD

The chart can be pulled from the reroll to examine the record. The reroll operates like a window-shade. A sudden release of tension on the unrolled chart will lock the reroll, allowing the record to be examined. To rewind the chart, first pull it forward slightly to release the reroll catch, then let it wind slowly on the reroll stick. Any amount of chart can be pulled from the reroll without damaging the mechanism.

COUPLING METERS

All chart drives are provided with a third wheel or hour shaft extending from one side to the other, and this shaft has ball fittings on each end for use with couplings. All except flush type meters have a clearance hole for a coupling in each side of the meter case. The coupling shaft is used for the quick trip and the external motor chart drive when meters are equipped with these attachments.

Synchronous chart drives should not be coupled to each other. The records on two or more recorders will be synchronized automatically if they are set to show the same time on the charts when the charts are running.

When the chart drive is to be driven from an external source of power the chart drive must be fitted with a third wheel clutch to permit the chart to run at the faster chart speeds without damage.

MAGNETIC SHIFT ATTACHMENT

Any rapid feed synchronous chart drive can be fitted at the factory with an attachment to change the speed of the chart drive from a certain speed in inches per hour to the corresponding chart speed in inches per minute by the operation of an external relay or push button. This device is essentially a solenoid mounted inside of the case, the plunger of which shifts the gears when the coil is energized. When the coil circuit is opened the chart is returned to the hour feed position by a spring. The coil terminals are brought out to the terminal board which is marked with the voltage and frequency of the supply necessary to operate this attachment.

CARE OF THE CHART DRIVE

Once a year the chart drive should be oiled. Do this when the chart has been removed from the instrument. Take off the cover plate under the chart and put a drop of oil on each pivot and gear including the differential gears and pivots inside of the case and the winding arbor bearings. The Esterline-Angus Company furnishes an oil for this purpose. It is put up in one ounce bottles with a screw cap which has a handy applicator wire attached. Oiling should be done by dipping the wire in the oil and then touching it to the bearing.

Do not use ordinary lubricating oil. Carefully wipe off any excess oil. If the instrument is used at very high temperatures it will be necessary to oil more frequently. A chart drive in which the bearings are allowed to become dry will not give satisfactory service.

Do not attempt to oil the synchronous motor. It is designed to give years of trouble-free service without any attention whatsoever. The gear case contains a generous amount of a special lubricant which will not oxidize or thicken. The oil used in the motor provides effective lubrication over a temperature range from 20 to 100 degrees Fahrenheit. For installations where the temperature drops below 20 degrees, the recorder should be installed in a heated cabinet.

The synchronous motor, which drives the chart will operate satisfactorily at temperatures as low as 20°F. but when a drive has been standing at a temperature from 20 to 45°F. for some time, the motor will run slow for a short period until it has time to warm up. For this reason, the chart should not be set to correct time of day until the motor has run about 15 minutes. After a running period of approximately 15 minutes, the heat developed in the motor will serve to keep it warm enough to run at synchronous speed.

CHART DRIVE CLEANING AND REPAIRS

In the course of time, chart drives will require cleaning, oiling, or repairs. The entire unit can be removed for repairs or returned to the factory without disturbing the rest of the recorder. Take out the four corner screws in the mounting plate, move the mounting plate slightly forward, and disconnect the motor supply leads from the small terminal block on the rear of the mounting plate. To remove the chart drives from a twin recorder, loosen both chart drives from the recorder and pull them out at an angle to disengage them from the coupling.

REMOVING THE SYNCHRONOUS MOTOR

To remove the motor from the chart drive, unsolder the two leads from the terminal block on the back side of the mounting plate. Remove the cotter pin or screw from the coupling which connects the motor to the gear train shaft. Take out the three screws which hold the motor to the winding bracket. Turn the motor around into such a position that it can be withdrawn from the front out of the space between the bottom edge of the writing table and the reroll spring winding shaft. If the chart drive is fitted with a magnetic shift attachment, all brackets, etc., must be removed to get the motor out. This procedure is also necessary to remove the magnetic shift attachment or to take it out for repairs. It is not practical to make any repairs to the motor outside of the factory. The entire motor should be returned to the factory for repairs or exchange.

In replacing the motor in the chart drive be sure and use the brass spacer on the rear mounting screw. It is a good plan to hang this spacer on the end of the screw after the screw has been shoved through the hole in the bracket. Screw this screw into the motor first and then the other screws will readily enter the motor feet. If the old style cotter pin coupling is used, the coupling must be slipped over the coupling balls while the motor is loose. When the two piece coupling is used it can be assembled over the coupling balls after the motor is tightened up. The coupling must always be free and not bind in any position.

REMOVING THE REROLL SPRING ASSEMBLY

To remove the reroll spring assembly, take out the reroll roller and unwind the spring by turning the winding crank in a counter-clock-wise direction. After the spring is completely unwound, remove the reroll gear train cover and the two intermediate reroll gears. Lay the chart drive on the left side so that the reroll spring is at the bottom, remove the worm gear cover, and drive the shaft leading to the reroll spring down and out of the worm gear. The chart drive must be in the position described, otherwise the thrust washer under the worm gear will prevent the shaft from being driven out. If the reroll spring is broken, we recommend returning for repairs, or replacing the complete reroll spring assembly, consisting of the spring barrel, reroll spring, and winding shaft.

ORDERING PARTS

When ordering parts or writing the factory about a chart drive, the style number and serial number should be given. These numbers are stamped on the chart drive nameplate. The synchronous motor nameplate identifies the motor and gives the voltage and frequency on which the motor is to be used.

ESTERLINE-ANGUS ALTERNATING CURRENT VOLTMETERS

AND (AC-DC) UTILITY VOLTMETERS

MODEL AW

Esterline-Angus AC and AC-DC voltmeter measuring elements are of the electrodynamometer type. Three different measuring elements are available; style numbers 340, 341, and 342.

The No. 340 element can be calibrated for any full scale AC voltage from 144 to 750 volts inclusive. These elements are calibrated for the frequency on which they are to be used, usually either 25 or 60 cycles.

AC-DC or Utility voltmeters also use the No. 340 measuring element. They can be calibrated for the same range of voltages as the AC voltmeters but they can be used on any direct current circuit or on frequencies up to and including 60 cycles alternating current.

The other two measuring elements are provided to supply the need for voltmeters having voltage and frequency ranges outside of the limitations of the No. 340 measuring element.

The style No. 341 measuring element is used to provide ranges from 50 to 225 volts and is calibrated for use on either 25 or 60 cycles. The style No. 342 element can be calibrated for any full scale voltage from 100 up to 500 volts, 25 or 60 cycles. It can also be calibrated for any specified frequency up to and including 400 cycles for voltage ranges of 150 to 500 inclusive.

The style number and serial number of the measuring element is stamped on the nameplate attached to the movement frame just under the inkwell. It is also shown on the instrument data sheet with all calibrating data.

CURRENT AND POWER CONSUMPTION

The current and power consumption of the various voltmeters and the reading of a 60 cycle voltmeter at full scale on different frequencies are given in the following table:

Item 1.

Style No.	Full Scale Current	Power Consumption	Reading of 60 cycle meter on various frequencies at full scale.						
		150 V. Range	Volts	DC	25Cy.	60Cy.	120Cy.	180Cy.	240Cy.
340	.13	11.5	150	1.02	1.01	1.00	.95	.87	.83
		Watts	300	1.01	1.00	1.00	.99	.97	.94
A.C.	Amp.	at 115	600	1.00	1.00	1.00	1.00	.99	.98
		Volts	750	1.00	1.00	1.00	1.00	1.00	.99
340		150 V.	Volts						
AC-DC	.13	Range							
Util-		11.5	150	1.00	1.00	1.00	.98	.95	.89
ity	Amp.	Watts	300	1.00	1.00	1.00	1.00	1.00	.99
		at 115	600	1.00	1.00	1.00	1.00	1.00	1.00
		Volts	750	1.00	1.00	1.00	1.00	1.00	1.00
		50 V.	Volts						
341	.38	Range							
A.C.	Amp.	12.	50	1.035	1.025	1.00			
		Watts	75	1.017	1.014	1.00			
		at 40	100	1.008	1.007	1.00			
		Volts	150	1.005	1.004	1.00			
		100 V.	Volts						
342		Range							
		11.5	100	1.005	1.004	1.00	.98	.96	.93
	.178	Watts	150	1.002	1.002	1.00	.99	.98	.967
A.C.		at 80	300	1.00	1.00	1.00	.998	.995	.99
	Amp.	Volts	500	1.00	1.00	1.00	1.00	.998	.996

RANGES SCALES AND CHARTS

Permanently installed voltmeters can be provided with any standard scale or chart range. See list of charts which can be supplied elsewhere in instruction book. Odd full scale voltage calibrations make it possible to use one of the standard chart ranges with certain potential transformer ratios which would otherwise require special charts.

Portable, multi-range voltmeters, 150-300-600 or 150-300-750, usually have the scales marked to correspond to the lowest range.

The ruling on AC voltmeter charts is quadratic. The voltage graduations are greatly expanded in the working range of the record but below 1/3 or 1/4 scale are not easily read. Due to the character-

Reading of 60 cycle meter on various

stics of AC circuits, there is a great advantage in this ruling for ost uses. AC voltmeters and ammeters both use the 1300 series record harts.

CCURACY

All of these measuring elements are calibrated to be accurate t any point on the chart to within 1% of the full scale value.

ULTIPLILRS AND LEADS

Voltmeters in portable and flush cases have the multiplier ounted on the back of the case for voltages up to and including 750 olts. Voltmeters in front switchboard and wall type cases have eparate multipliers for ranges up to and including 750 volts.

Portable, or other types of voltmeters with the No. 340 measuring element, can be supplied for higher voltages by using separate ultipliers.

Five foot leads are furnished with all portable voltmeters unless binding post terminals are ordered. Any voltmeter can be supplied with binding post terminals and then the meter can be used with ny wire for making the connections.

ERO ADJUSTIENT

A zero adjusting lever is located at the bottom of the meter with a pointer extending out over the nameplate. The zero should be set with the voltmeter disconnected. The zero should be carefully adjusted so the pen point writes on the zero line on the chart. While making the adjustment tap the pen table with the finger.

AMPING

This instrument is equipped with adjustable damping. It has been set at the factory to the proper strength to prevent over-shooting on sudden swings. This setting should not be changed unless special conditions warrant it and the change should be made by someone who understands the effect of changing the damping on recording instruments.

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voltmeters and ammeters both use the 1300 series record
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All these measuring elements are calibrated to be accurate
on the chart to within 1% of the full scale value.

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meters in front switchboard and wall type cases have
multipliers for ranges up to and including 750 volts.

, or other types of voltmeters with the No. 340 mea-
, can be supplied for higher voltages by using separate
.

The test leads are furnished with all portable voltmeters
post terminals are ordered. Any voltmeter can be sup-
plied with binding post terminals and then the meter can be used with
any external leading the connections.

extending out over the receptacle. The zero should be
voltmeter disconnected. The zero should be carefully
the pen adjustment tap the pen table with the finger.

This instrument is equipped with adjustable damping. It has
been set at the factory for proper damping. If any
current it and the change should be made by persons
the effect of changing the damping on recording in-
.

If it is desired to change the degree of damping, remove the chart drive from the instrument by taking out the four corner screws. This gives access to the damping mechanism at the lower end of the electrical movement. The two magnets are each pivoted on a vertical axis and held from turning by friction. Each magnet has a pointer projection on the lower edge. The pointer reads on a graduated scale marked 1 to 5. When the pointers are at No. 1, the least damping is obtained. No. 5 setting gives the heaviest damping.

The magnets can be moved by turning them with the thumb and first finger. The degree of damping is designated by the number at which the pointer is set, and this number is shown on the data sheet as the damping number.

IMPORTANT

Both damping magnets must be set to the same reading on the graduations to avoid errors in the registration of the instrument.

COMPUTING SCALE RANGE

When used without potential transformers, or on direct current, voltmeters are direct reading.

When potential transformers are used, the transformer secondary should be connected to the 150 volt tap on the voltmeter and the full scale reading is the range of the instrument alone, multiplied by the ratio of the transformer.

For example: To find the full scale reading of an alternating current voltmeter with a potential transformer having a ratio of 2300 volts primary to 115 volts secondary:

Range of meter alone, 0-150 volts
Ratio of potential transformer 2300 - 115 = 20 to 1
Full scale range of meter 20 x 150 volts = 0-3000 volts

CARE OF THE MEASURING ELEMENT. ELECTRODYNAMOMETER TYPE

If the moving element has a tendency to stick, and not swing freely, the trouble may be eliminated without returning the instru-

INSTALLATION, USE, AND CARE OF

MODEL AW EXTERNAL MOTOR DRIVE ATTACHMENTS

In the study of events of short duration or in the analysis of rapidly occurring events or rapidly changing quantities, it is necessary to employ chart speeds much higher than those involved in ordinary work. In addition, there must usually be some scheme of controlling the high chart speed automatically and often remotely, initiating it from the disturbance to be studied or at a certain point in the test cycle. For these purposes, where a combination of high chart speed and action controllable automatically from a remote point are required, the external motor drive attachment is used. These attachments are employed in such diverse fields as the recording of disturbances in electric power systems; study of water hammer; continuous automatic life testing of brakes; supervision of electric welding; time studies on high speed machines, and monitoring of automatic radio transmitters.

DESCRIPTION

The external motor drive attachment consists of a specially built fractional horsepower motor together with a gear box and control mechanism housed in one of the motor endbells, attached to the outside of the instrument case by means of a vibration-absorbing rubber mounting. The slow speed shaft of the gear train is coupled to the third wheel shaft of the recorder. In some cases this coupling is through an over-running clutch, in other cases it is direct. Some types are fitted with an electro-magnetic trip coil and a manual trip lever, where other types do not include this feature.

In the first type of attachment, to initiate the high speed action, the gears are engaged by energizing the trip coil. In the second type, high speed action is initiated by starting the electric motor. In either case the external motor attachment takes control of the chart and propels it at high speed. This transfer of control is made possible by a clutch on the third wheel shaft in the instrument chart drive assembly, which clutch permits the third wheel shaft and drive roll to be revolved at higher-than-normal speed without damaging or stopping the clock which provides the normal feed.

TYPES AVAILABLE

There are five types of external motor drive attachments available. Two of these speed up the chart to 60 times its original speed and provide a high speed in inches per minute equal to that at which the chart was originally travelling in inches per hour. Three attachments speed up the chart to 3600 times its original speed, providing a high speed in inches per second equal to the original chart speed in inches per hour.

Motors are available for operation either on alternating or direct current. DC motors are available for 12, 24, 115 and 230 volts. These are shunt wound motors and are provided with a speed control rheostat. This rheostat is mounted in the recorder case on portable instruments, but is furnished as a separate item for panel mounting on switchboard, wall and flush type instruments. AC motors are available for 115 and 230 volts, 60 cycles only. These are single phase, synchronous motors.

On both minute and second speed drives, one type of attachment uses a constantly running external motor which is thrown into gear by action of the manual trip lever or by energizing the trip coil. Another type, available in both minute and second speeds, has the gears permanently engaged, employs no trip lever or solenoid, but controls the high speed action by starting and stopping the motor. The third type, available in second speeds only, is thrown into gear when the trip coil is energized, but once the mechanism is tripped, it locks into high speed and runs for 24 seconds, then automatically disengages, resetting the chart to the correct time of day. This is the QUICK-TRIP device used for recording disturbances and resetting the chart to time when the disturbance is over.

On portable, front switchboard and wall type instruments, the entire external motor drive attachment is visible and accessible from the front of the board and its action may be tested at any time by operating the manual trip lever. On flush instruments, the entire attachment is behind the switchboard and servicing or testing must be carried out from that point.

The following table shows the various types of external motor drive attachments available.

Type	High Speed	Motor	Trip Coil	Time Reset	Sequence of Operation
*11-S	Second	Continuous Running	Yes	Yes	Impulse to trip coil initiates high speed action and maintains it for 24 seconds.
13-S	Second	Continuous Running	Yes	No	High speed action maintained as long as trip coil is energized.
14-S	Second	Intermittent	No	No	High speed action maintained as long as motor is energized.
11-M	Minute	Continuous Running	Yes	No	Same as 13-S
14-M	Minute	Intermittent	No	No	Same as 14-S

*This device is commonly know as a Quick Trip attachment

INSTALLATION

CONNECTIONS: Connect the motor through a fuse block and a switch to a circuit of the same type and voltage as shown on the motor nameplate. For Types 14-M and 14-S, the motor circuit must be wired through the pushbutton, relay, contactor or whatever device controls the high speed action. On DC motors for switchboard, wall or flush type instruments, the speed control rheostat must be separately mounted and connected in series with the power supply of the motor. On Types 11-M, 11-S and 13-S, provided with a trip coil, this coil should be connected to a circuit of the same type and rating as shown on the coil nameplate, wiring it through the relay, contactor or other device which controls the high speed action.

CURRENT CONSUMPTION OF MOTOR AND TRIP COILS

Motor Rating	Running Amperes	Stalled Amperes	Trip Coil Amperes
12 V. DC	1.40	20.0	1.30
24 V. DC	.70	13.0	.68
115 V. DC	.19	1.6	.14
230 V. DC	.145	1.1	.07
115 V., 60 Cy.	.66	6.0	.25
230 V., 60 Cy.	.33	3.0	.13

SPEED ADJUSTMENT: AC motors are synchronous and run at 1800 RPM on a 60-cycle circuit. DC motors are provided with a speed control rheostat, which should be adjusted for a motor speed of 1800 RPM. On the continuously running motors, used in Types 11-M, 11-S and 13-S, this adjustment should not be made until the motor has run one full hour and has reached normal operating temperature. This adjustment can be made either by a speed counter applied to the motor shaft or by checking the amount of chart run off in a given time.

NARROW FLUSH MOUNTING: Where narrow flush instruments (designated by the letters AW-N or AWT-N) are fitted with the external motor drive attachment, this attachment must be removed before the instrument is mounted on the panel, and replaced afterwards. When mounting these instruments, first remove the attachment from the case, using the two wrenches provided. After the instrument has been mounted on the panel, the motor drive device should be re-attached to the meter case. Be sure that the coupling between the motor drive and the instrument has end play and is free in all positions. Do not draw the mounting nuts too tight as this will destroy the cushioning effect of the rubber mounting. In these narrow flush instruments, it is necessary to loosen the motor drive device to permit withdrawal of the coupling in case the chart drive is to be removed from the instrument. It is not necessary to remove the motor drive device entirely to take out the chart drive.

OPERATION

CHANGE GEARS: The change gears on the clock determine the chart speed both for the self-contained hourly feed chart drive and for the external motor drive. For example, with an 18-tooth driving gear and a 72-tooth driven gear, the normal speed will be 3/4" per hour and the high speed will be 3/4" per minute or per second. For the minute speed devices, chart speeds up to 6" per minute are available. For the second speed devices, a chart speed of 3/4" per second is recommended. This speed is high enough to record any swings of which the recording pen is capable, it makes time measurements easy since the space between each pair of time arcs is exactly 1 second, and it does not require such critical maintenance of the writing system as is the case with higher speeds. Speeds higher than 3" per second should not be used on any instruments except operation recorders.

The following table shows the corbination of change gears to use to obtain different chart speeds, the amount of chart consumed per hour or per minute and the length of time that one chart will last at these speeds.

Minute Feeds

Inches Per Min.	Driving Gear	Driven Gear	Feet of Chart Per Hour	Total Running Time of Chart in Hours
3/4	18	72	3.75	26.7
1 1/2	30	60	7.5	13.3
3	45	45	15.	6.7
6	60	30	30.	3.3

Second Speeds

Inches Per Sec.	Driving Gear	Driven Gear	Feet of Chart Per Minute	Total Running Time of Chart in Minutes
3/4	18	72	3.75	26.7
1 1/2	30	60	7.5	13.3
3	45	45	15.	6.7

MAINTENANCE

MOTOR: In those attachments having continuously running motors the motor bearings should be lubricated every six months with ball bearing grease. The bakelite cover over the gear compartment should be removed and a light, high-temperature grease should be used sparingly on the worm and gears, and in the case of the 11-S "QUICK-TRIP", on the cam and latch.

The brush and brush holders of DC motors should be removed and cleaned at regular intervals. The brushes should be renewed if

badly worn. When ordering replacement brushes, state serial number on motor nameplate. If the commutator becomes blackened, it should be cleaned with a dry cloth. If rough, it should be polished with fine sandpaper while the motor is running.

WRITING SYSTEM: Instruments with high speed attachments, particularly where second speeds are used, require more careful attention to the inking system than is the case with the ordinary recorder operating at hourly speed only. This is due to the much more rapid flow of ink required in these instruments and the fact that this increased ink flow must often start very suddenly. In such instruments we recommend that the ink well and pen be emptied, washed and refilled every week.

Use only Esterline-Angus Red Graphic Meter Ink, keeping the bottle capped when not in service. When washing the ink well, pry off the ink well cover so that any solid deposit or thickened ink can be removed. See that the two vent holes in the corners of the ink well cover are open. Expel ink from the pen element and glass writing pen and wash these parts with water, by use of the compression bulb pen filler. Examine the writing tip of the glass pen against the light. If it is stopped up and water will not clear it, insert a new glass pen. Refill the ink well with fresh ink and put it back in the instrument. (The ink may be diluted with as much as one part ink to one part water if desired, although such dilution will cause more rapid evaporation in the ink well where the internal temperature is high). Expel the water from the pen element, reinsert the pen element and prime it with the pen filler. Make sure that all air bubbles have been removed and see that the glass writing pen is exactly perpendicular to the chart. If the pen is not perpendicular it may write when the pen swings in one direction and fail to write when the pen swings the opposite way.

The glass pen must be smooth on the end. If it is chipped, inking trouble will result. The writing surface of the pen can be smoothed by wet stoning with a find Arkansas stone, but it is best to replace entirely any glass pen having a chipped point. When replacing a glass pen, be sure to insert it to the correct length as shown by the arc line on the pen table.

The pen pressure must be sufficient to hold the pen on the chart even when it is swinging rapidly. For high speed recording, the pen should bear on the paper somewhat heavier than for the ordinary instrument. The pen pressure can be increased by screwing the balance weights forward, but the pen should always bounce slightly off the paper when the pen table is tapped with the pen full of ink. If the pen is set so heavy that it will not bounce, sluggish operation and inaccurate recording may result.

Adjustments are properly made at the factory, but the above instructions should be followed carefully if the adjustments have been changed in the field, if a new glass pen has been installed, or in case of inking trouble.

ARE OF CHARTS: For instruments with high speed attachments, it is important that the chart be kept clean and dry, hat it be threaded properly in the instrument and properly attached o the reroll and that the reroll spring be fully wound each time a ew chart roll is inserted. These precautions are necessary so that he chart will feed smoothly over the writing table and will be kept aut at all times. If the chart bulges or wrinkles due to being amp or improperly threaded in the instrument, the pen will skip hen swinging rapidly.

Instruments to operate at high speed must be clean and dry. amp charts or dust on the chart surface or on the writing pen will nterfere with proper high speed recording. Keep the case cover losed at all times.

In instruments (particularly quick trips) where the high speed ction occurs only intermittently, the instrument should be examined t regular intervals to see that there is enough chart left on the upply roll. It is a good practice to date the record daily to dentify the day of occurrence of any high speed operations.

SPECIAL PRECAUTIONS: REPAIRS

If an external motor drive device is to be added in the field o an instrument not originally so equipped, care must be taken to ee that the self-contained chart drive contains a third wheel lutch. If this clutch is not present, damage will result. This lutch can be added to existing chart drives at the factory.

If the worm and gear chatter at high speed, this is usually an ndication of an excessive load on the device. The gear train is uilt so that if an excessive load is applied, the gears will auto- atically force themselves out of engagement. In such a case, look or binding of the coupling between the external motor device and he instrument. Do not attempt to drive several instruments from ne external motor attachment. Also check the voltage applied to he tripping solenoid. Low voltage may reduce the thrust of the olenoid to the point where it will not hold the gears in engagement.

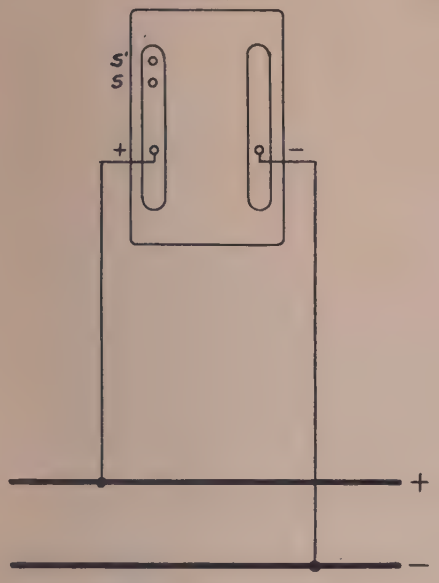
In case of any unsatisfactory operation not readily corrected .. the field, communicate with the factory, stating meter serial umber, and describing the difficulty experienced. This attachment an be removed and returned to the factory for repairs without dis- ontinuing the use of the recorder on ordinary chart feeds.

DIAGRAM OF CONNECTIONS
FOR MODEL AW

ESTERLINE-ANGUS PORTABLE AND FLUSH TYPE GRAPHIC VOLTMETER.

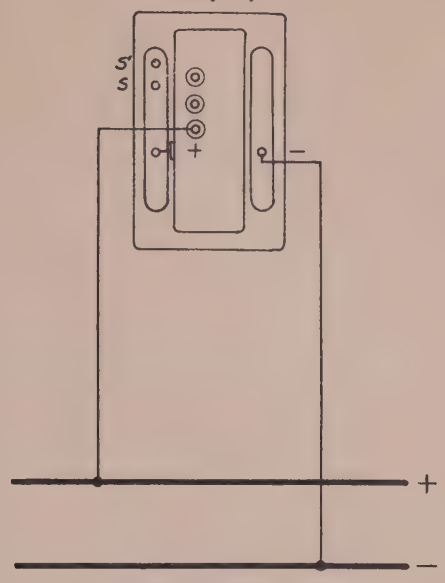
BACK VIEWS.

FIG. 1.



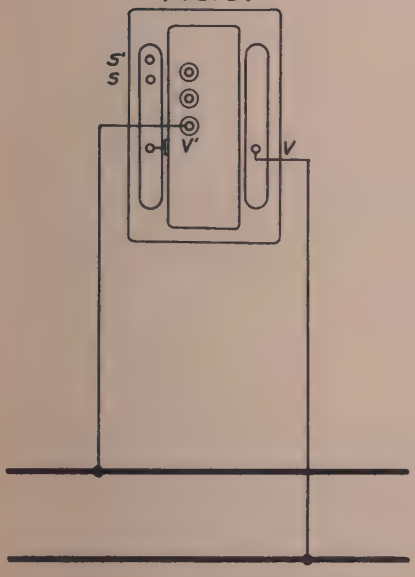
DIRECT CURRENT
WITHOUT MULTIPLIER.

FIG. 2.



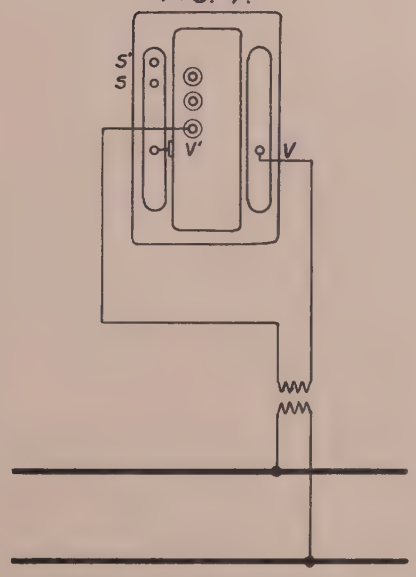
DIRECT CURRENT
WITH MULTIPLIER.

FIG. 3.



DIRECT AND ALTERNATING
CURRENT.

FIG. 4.



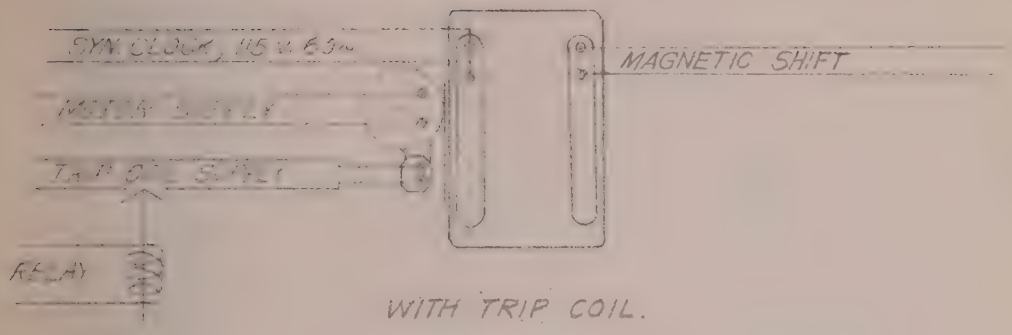
ALTERNATING CURRENT
WITH POTENTIAL TRANSFORMER.

VOLTAGE TERMINAL - OR V IS COMMON FOR ALL RANGES, AND MARKING ON OTHER TERMINALS INDICATES THE RANGE FOR THOSE TERMINALS.
METERS WITH SYNCHRONOUS CLOCK- CONNECT CLOCK SUPPLY TO TERMINALS S AND S'.

DIAGRAM OF CONNECTIONS
FOR
EXTERNAL MOTOR CHART DRIVE ATTACHMENT
AND MAGNETIC SHIFT
ON MODEL AW
ESTERLINE ANGUS PORTABLE TYPE RECORDERS.

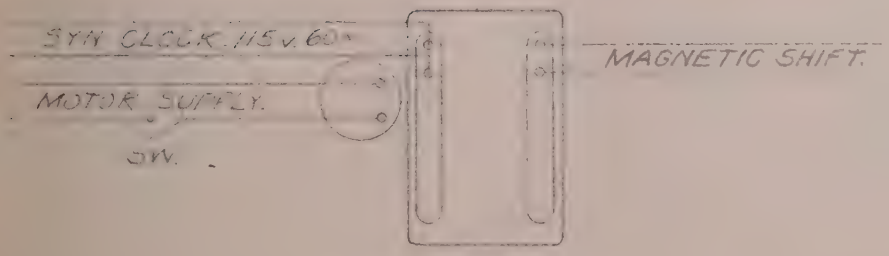
BACK VIEWS.

FIG. 1



WITH TRIP COIL.

FIG. 2



WITHOUT TRIP COIL.

NOTE, FOR CIRCUIT CONNECTIONS TO METER, SEE SPECIFICATION SHEET FURNISHED WITH METER.

DEC 17 1943

S 2822.

LIST OF
SUPPLIES, ACCESSORIES AND PARTS
FOR MODEL AW GRAPHIC INSTRUMENTS

CHART - Specify by chart number if known. Where an existing chart is to be duplicated, the number will be found on the chart at 3-foot intervals. If chart number is unknown, specify range, chart speed and serial number of instrument. All charts are 103 feet long. At 3" per hour (the speed most frequently used) one chart will last for 15 days. Price:

	STANDARD CHARTS (Printed) NET EACH	1000-X CHARTS (Blank) NET EACH
Lots of 1-23	$ 1.50	$ 1.20
" " 24-47	1.35	1.10
" " 48-95	1.20	1.00
" " 96-249	1.05	.90
" " 250-499	.90	.80
" " 500-999	.80	.75
" " 1000-1999	.72	.70
" " 2000-4999	.68	.66
" " 5000 or Over	.64	.62

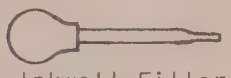
INK - Specify whether to be furnished in 2-oz. or 16 oz. bottles and whether red or green is desired. A 16-oz. bottle should be on hand for each 12 to 24 charts. Price:

2 oz. bottles, lots of 1-9	$.75 net each
2 oz. bottles, lots of 10-99	.60 " "
2 oz. bottles, lots of 100 or more	.50 " "
Pint bottles, lots of 1-9	2.50 " "
Pint bottles, lots of 10-99	2.25 " "
Pint bottles, lots of 100 or more	2.00 " "

GLASS PEN POINT, #82C - A spare glass pen point should be kept on hand for each meter. Price:

Lots of 1-9	$.75 net each
" " 10-99	.60 " "
" " 100 or more	.50 " "

INKWELL FILLER - Used to transfer ink from bottle to inkwell. Price: 25¢ net.



Inkwell Filler

PEN FILLER - Used for priming pen. Also for cleaning glass pen and pen element. Price: 75¢ net.

Pen Filler

INKWELL, #8516 - Main inkwell for all Model AW instruments except operation (time) recorder. Not for chronograph pen if one exists. Price: $3.00 net.

CLOCK WINDING CRANK, #8290 - Also for winding reroll spring on Model AW synchronous motor and "phantom" chart drives. Price: 75¢ net.

CLOCK OIL, 1/3 oz. bottle - For all chart drives. Price: $1.00 net.

AW ACCESSORY KIT - Includes 2-oz. bottle red ink, glass pen point, inkwell filler and pen filler, all in round cardboard container. Price: ~~$2.25~~ 2.50 net.

All above prices are f.o.b. Indianapolis, Indiana. Terms: Net 30 days.

over

PEN ELEMENT, COMPLETE WITH GLASS PEN POINT,

#8510 - For measuring element on all Model AW instruments except operation (time) recorder. Price: $3.00 net.

#9892 - For chronograph pen (where one exists) on instrument with serial number 31000 or above. Price, with inkwell: $5.00 net.

#____ - For chronograph pen (where one exists) on instrument with serial number below #31000. Serial number of instrument must be specified when ordering. Price, with inkwell: $5.00 net.

#9056 - For operation (time) recorder serial #25000 to #30782. Price: $2.50 net.

#9856 - For operation (time) recorder serial #30783 and above, Price: $2.50 net.

LEADS - For portable instruments and for current circuits of DC wattmeters and DC ammeters. Specify serial number of instrument and lead length. Standard length is 5 feet. Price:

Current Leads, 5 feet long, No. 4 wire (for DC or Util. wattmeters) - $3.00 each
Current Leads, 5 feet long, No. 8 or No. 10 wire - - - - - - - - - - - 2.50 each
Potential Leads, 5 feet long, No. 14 wire - - - - - - - - - - - - - - 1.50 each

BRUSHES FOR EXTERNAL DC MOTOR,

A20 - For 125 volt or 250 volt motor. Price: 30¢ net per pair.
M15 - For 12-48 volt Motor. Price: 30¢ net per pair.

BRUSH AND SPRING ASSEMBLY FOR TACHOMETER GENERATOR,

2 - #6332 Brushes and 1 - #6336 spring - for Model C tachometer generator. Price: $4.00 net lot.
2 - #5332 brushes and 1 - #5374 spring - for Model A or Model B tachometer generator. Price: $4.00 net lot.

LAMP FOR FLUSH METER,

115 volt - Price: 50¢ net.
230 volt - Price: 75¢ net.

INSTRUCTION BOOK - Covers care and use of instrument and provides wiring diagram. Serial number of instrument must be specified when ordering. Price: "No charge".

All above prices are f.o.b. Indianapolis, Indiana. Terms: Net 30 days.

SHIPMENT: 1 to 5 days.

Send order to: THE ESTERLINE-ANGUS COMPANY, INC.,
c/o Nearest representative (see last page of catalog for name and address)
or
THE ESTERLINE-ANGUS COMPANY, INC.,
P.O. BOX 596,
Indianapolis, 6, Indiana.

Form #348-P

THE GRAPHIC

THE ESTERLINE-ANGUS CO., INC. • INDIANAPOLIS • BULLETIN NUMBER 436-A

How to Make Plant Surveys

WITH GRAPHIC INSTRUMENTS

WHEN a manufacturer wants to improve a product, he makes it the subject of research. The big job in manufacturing is to make an efficient application of power and labor to the processes of production. Here is a place where research pays. You conduct research to improve the things you make; why not research to improve the making? You will be surprised to find what can be accomplished by actually testing the efficiency of this combination of men and power and machines, which we call a manufacturing plant. At their best, plant surveys are a process of continuous research throughout the plant, to discover where improvement can be made. Well done, such surveys as are described in this bulletin turn up losses and wastes in power and labor which can be overcome; they disclose where maintenance is needed; where production processes can be bettered. Graphic instruments make studies of this kind possible because they record what actually takes place, giving all the characteristics of performance. They work without being watched, so that one individual can be obtaining information at different places at the same time.

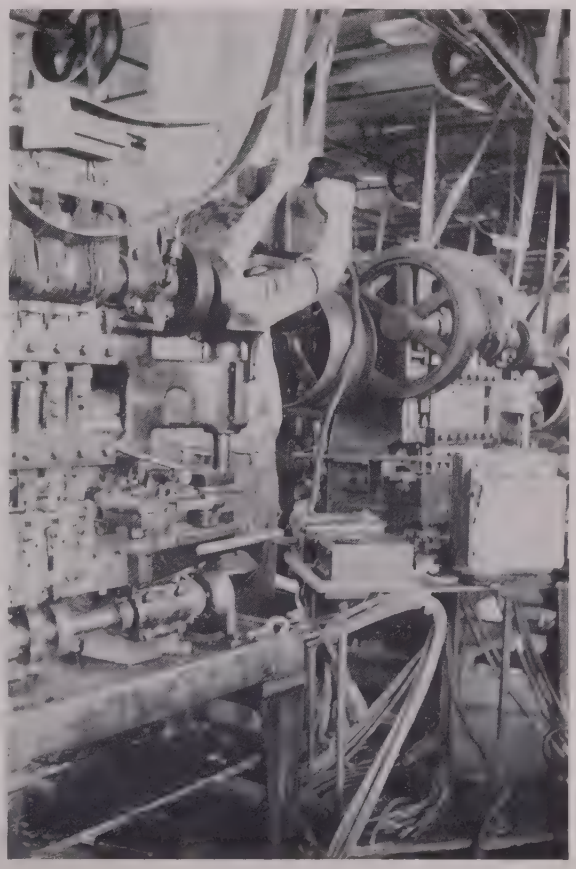


FIG. 1—*This illustration shows the man making a plant survey in the act of connecting his graphic meter in a motor circuit.*

WHY SURVEYS ARE PROFITABLE

The purpose of this bulletin is to show briefly what may be accomplished by a continuous and systematic study of plant operation, and to suggest the procedure which should be followed. It is understood, of course, that no two plants have precisely the same problems, but the principles which apply to the betterment of plant operation are the same, regardless of the character of the plant or its product.

The Kind of Information Obtained

Graphic surveys are made for the purpose of obtaining any information which is valuable in improving the operation of the plant by reducing waste, improving performance, lowering costs or bettering the product. In general, they have to do with four elements which enter into the cost of a product, namely, condition of equipment, power use, employee time and the handling of equipment by workmen. Perhaps an illustration of each of these phases of plant study will make clearer what we mean.

Checking Condition of Equipment

An electric motor draws power from the supply line in almost direct proportion to the work it has to do. By measuring this flow of energy to the motor, we can learn just what it is being called upon to do. A graphic record of the energy taken by the motor gives a picture of just what is going on in the machine which the motor is driving. Any change in the condition of the machine usually causes a change in the character of the record, so that occasional "check-ups" with graphic instruments enable the engineer to "spot" causes of future trouble long before breakdown occurs.

As an example, here are the graphic meter records from a hot lead pump. Figure 3 shows the chart obtained in the course of a survey. This chart was so different from those obtained in previous surveys that the pump was dismantled. Examination showed that some of the internal parts were in bad condition. Figure 2 is a chart made after the machine had been repaired. The test made in time undoubtedly saved the pump from being wrecked.

Stopping Power Waste

If water leaks from a faucet, the loss is evident, but electrical energy can be wasted day after day, and no one will realize the fact, unless someone is looking for the waste. Motors may be started ahead of time or be permitted to run after hours. Lights and equipment may be used

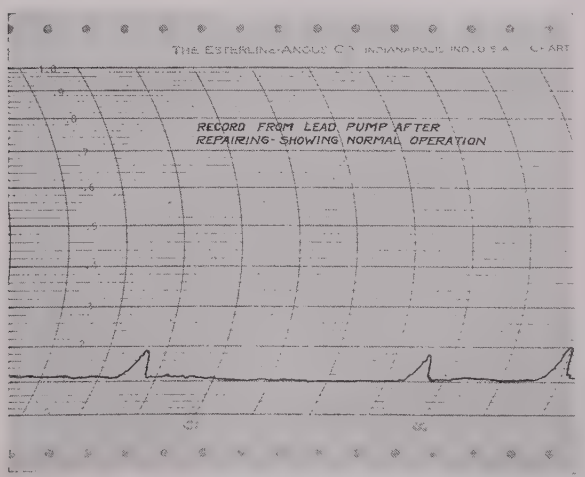


FIG. 2—*This chart shows the normal operation of a pump for handling hot lead in a storage battery plant. The chart in Figure 3 is from the same pump.*

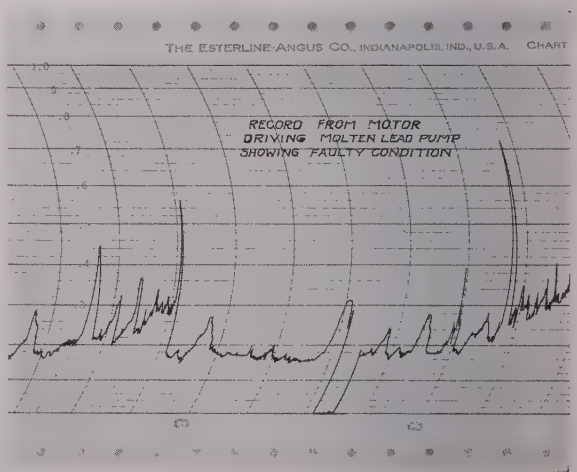

THE ESTERLINE-ANGUS CO., INDIANAPOLIS, IND., U.S.A. CHART
RECORD FROM MOTOR
DRIVING MOLTEN LEAD PUMP
SHOWING FAULTY CONDITION

FIG. 3—*This is the chart which showed that the lead pump was out of condition. When the pump was taken apart the cause of the trouble was apparent.*

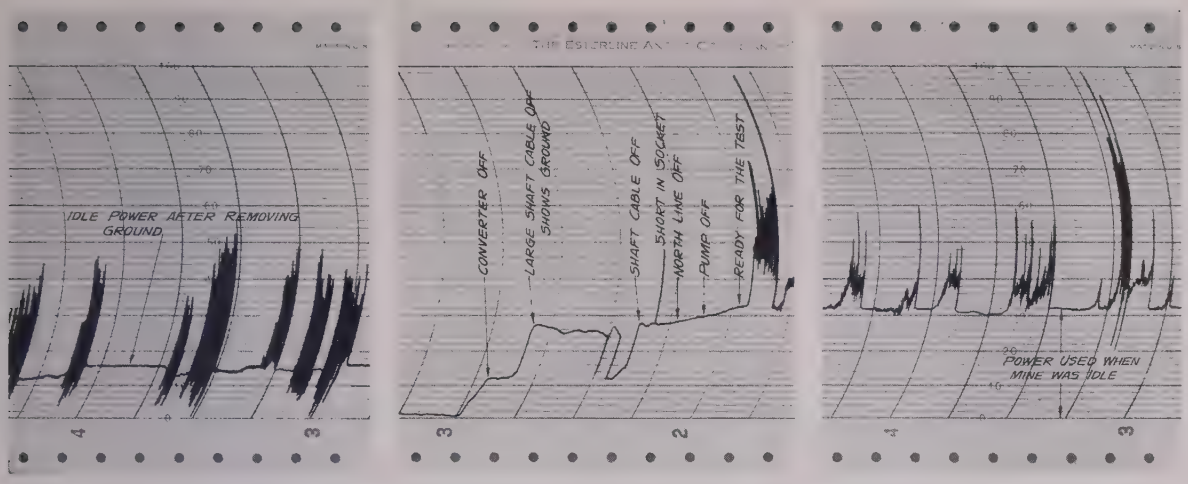


FIG. 4—*The right-hand portion of this chart shows the idle power in a coal mine. The middle portion shows the effect of opening the feeder switches. The left-hand portion shows the idle load after the ground was removed.*

nights and Sundays; grounds may exist; friction losses may mount to abnormal proportions. Occasional surveys with graphic instruments will bring to attention anything unusual in the use of electrical energy.

A graphic wattmeter was left in the main feeder circuit of an Indiana coal mine overnight, and the chart showed a continuous flow of power throughout the night when the mine was idle, as shown in the right-hand portion of Figure 4. The next morning the circuit switches were opened one at a time, and the loss was found to be on the line to the main shaft. The ground was discovered and removed, and a loss of energy amounting to some $1,800 per year was stopped.

Discovering Labor Losses

We have already mentioned the fact that the electrical energy drawn by a motor increases and decreases with the work the motor is called upon to do. Here then is a simple and convenient way to tell how much productive work is being done by the motor-driven machinery in a plant. A graphic wattmeter connected to the power supply circuit to a department using motor-driven machines often gives a chart which shows an unsuspected loss of productive effort.

For example, here is a chart obtained in a manufacturing plant in Milwaukee between the hours of 12 noon and 4:30 P. M. The load during the noon hour was 84 kilowatts. Work was

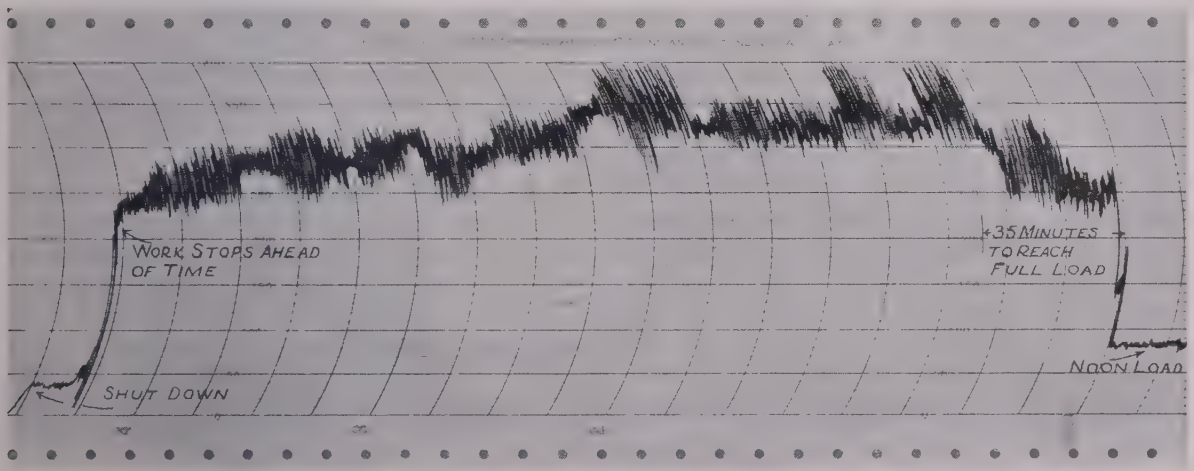


FIG. 5—*This record shows how labor losses may be detected with graphic instruments. This is the afternoon record of a plant supposed to start at 12 o'clock and quit at 4:30. It took 30 minutes to get going at full production, and quitting started at 4 P. M. Loss, $30,000 a year.*

supposed to start at 12. A few minutes before 12 several of the motors were started, and several minutes after 12 the load was only 50 per cent of normal. Gradually work got under way, but it was actually 12:35 P. M. before everybody was at work. Then at 4 o'clock work began to slacken up, so that shutting down was a gradual process until 4:30 P. M., when the motors were stopped. The engineer who sent us this chart estimates that the loss of time represented by this chart amounted to approximately $100 per day, or $30,000 annually. No one knows how long this condition had existed, and it would probably be going on today had not this survey been made.

Handling of Equipment

There is a great deal of manufacturing equipment which is not automatic, but on the other hand, the skill of the operator is a factor in the production scheme. Workmen develop notions of their own: some are inclined to become indifferent or careless: in some instances the man's understanding of the requirements may be faulty. The advantage of using graphic instruments lies in the fact that records can be taken over sufficiently long periods of time, the charts produced by different men can be compared, and the faults can be pointed out to the men. Sometimes it pays to put the instruments in permanently, locating them so the operator can observe the record he is making, but the way to find the faults to be corrected is by a survey of plant operation at regular intervals.

A good example of this phase of survey work was recently sent us by the engineer of a cement plant. A two-speed rotary kiln was operated continuously by three shifts of men. The charts obtained showed that the three crews had widely different ideas of how the same equipment should be handled. The result was lack of uniformity of the product, and reduced output.

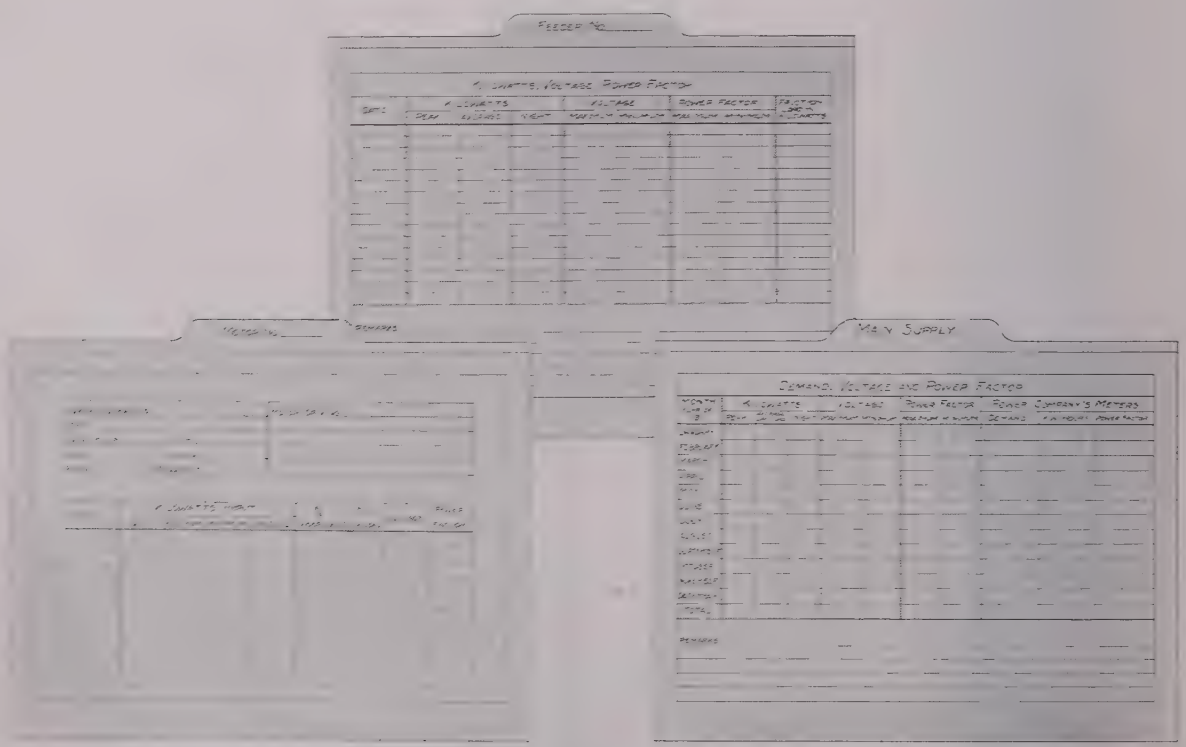


Fig. 6—Here is a simple way to preserve the charts taken in surveys. Use manilla letter file folders with spaces for data mimeographed on the front. Give each circuit and motor a separate number and file. Label each record chart, date it and place it in the proper file.

PRESERVING THE SURVEY RECORDS

In order that the work may be done systematically and records kept in a form so that they can be conveniently used, a number of engineers have worked out systems of forms and records which they are using to this end. The first step is usually to prepare a simple drawing, showing the power circuits, with each motor and piece of electrical equipment given a number. A single line is usually used to represent a circuit. Some engineers indicate the size of conductors and the horsepower of motors on this diagram, but this is not essential.

To provide a place for the records taken on each piece of equipment from time to time, and to assemble in one place all the data regarding each unit, it has been found desirable to use standard letter file folders, ruled and lettered, so as to provide spaces for the information obtained. These folders are inexpensive, and can be prepared by the mimeographic or "ditto" process. In cases where whole charts need to be preserved, they can be stamped and replaced in the boxes in which they are originally received.

The record charts from a given machine are dated and numbered to correspond with the number of the machine or circuit on which the record was made, and after the data required are taken from the record and placed in the blank spaces on the folder the chart is placed inside the folder for future reference. It is quite essential that each record chart have on it sufficient notes to make it possible to identify it later. Each test made in a survey usually uses only a few feet of chart, and it is the practice of many engineers to cut or tear off each section, stamp it with a rubber stamp, a sample of which is illustrated on page 8, and then fill in the blank spaces. Some engineers, especially those concerned with maintenance, prefer to have on the face of the folder a space for keeping a record of the dates and character of repairs made. Having provided these simple forms, and with the necessary instruments available, a systematic study of plant performance can be begun.

INSTRUMENTS FOR SURVEY WORK

The instruments used for survey work generally are graphic wattmeters, voltmeters, ammeters and power factor meters. Unquestionably graphic instruments are vastly superior to indicating instruments for this kind of service. In the first place, they do not require a man to stay with them. With graphic meters all that is required is to connect the instruments in the circuit and leave them to operate as long as is desirable. This means that one man can keep a number of instruments in operation all the time without interfering with his other duties.

Again, much of the information obtained from graphic records comes out of the characteristics of the record itself. The shape of the curve, the values recorded with respect to time, etc., are all important, and these are data which can be secured only with graphic recorders. In order to be able to obtain good records of rapidly varying quantities, we recommend that the wattmeters and ammeters be equipped with rapid feed clocks by which the charts can be fed several inches per minute when necessary. Rapid chart speeds are usually not required on voltmeters and power factor recorders.

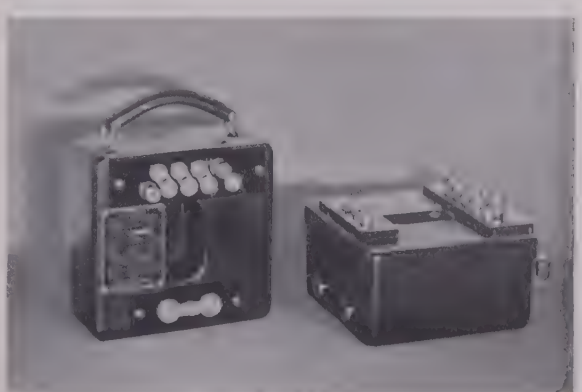


FIG. 7 *On alternating current circuits, current transformers are used to give the instruments the proper ranges. These Esterline-Angus transformers are metal-clad, and they have nine current ranges.*

FIG. 8—*This illustration shows the Esterline-Angus portable graphic meter, designed especially for survey work. It is unquestionably the most dependable graphic instrument in the world.*

Instruments for survey work should preferably be of the portable type, so that they can be moved from place to place conveniently. They should have voltage ranges which will adapt them to the voltages of the different power and lighting circuits of the plant. If both alternating and direct current are in use, the wattmeters and voltmeters should be of the "utility" type, accurate on both AC and DC circuits.

The accessories required likewise depend upon whether both alternating and direct current circuits are to be tested. Standard wattmeters, AC ammeters and power factor meters have a current range of 5 amperes, and on alternating current circuits transformers are used to give the instruments the proper current capacities to handle the different circuits to be tested. This company makes a current transformer having nine primary ranges, namely, 10, 12.5, 25, 50, 100, 160, 200, 400 and 800 amperes, the use of which gives a single instrument a wide range of capacities. These current transformers have sufficient volt-ampere capacity to operate both a wattmeter and an ammeter at the same time.

To give the wattmeter and DC ammeter the required capacities on direct current circuits, shunts are used. These can be furnished in any desired current rating.

In order to reduce the variety of charts required for miscellaneous tests, a chart of one range is usually used in such instruments as ammeters and wattmeters and a proper multiplier used in taking the values from the record chart. Extra copies of charts can be made by blue printing.

Many of our customers have devised special trucks or carts on which the instruments and the accessories are permanently mounted and connected. In some plants jacks have been provided on each circuit, so that the instruments can be plugged in quickly.

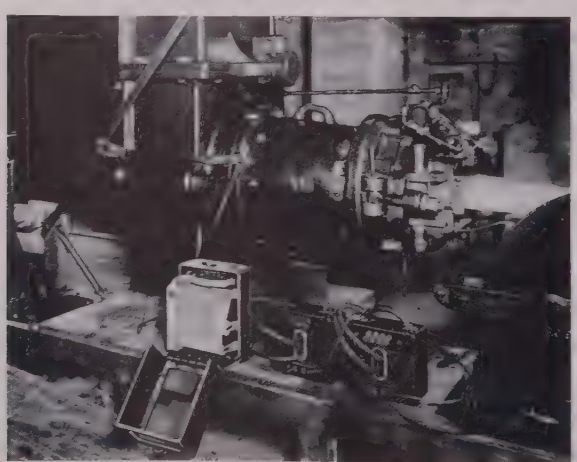


FIG. 9—*Here is a picture of a survey in progress in a plant manufacturing building brick. The transformers and graphic meter are in the circuit of the motor driving the pug mill.*

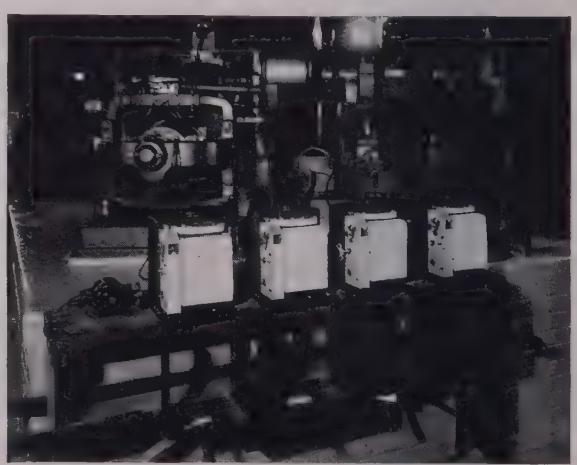


FIG. 10—*Four instruments are in use here, recording kilowatts, voltage, power factor and amperes. This picture was taken in the penthouse of one of Detroit's largest office buildings.*

STUDYING THE TOTAL LOAD

There is certain valuable information to be obtained from the records of total power consumption. It is on account of this that many engineers prefer to place graphic instruments permanently in the main circuit, rather than to make only periodic tests of the total power load. One thing which makes the total load an important consideration is the maximum demand charge. The graphic record of total consumption provides a check on demand measurements, gives prompt information on any tendency toward unnecessary increase in the maximum demand, and shows the result of any steps taken to reduce the peak load.

Frequently the pyramiding of peak loads, due to simultaneous starting of equipment or the operation of intermittently used machinery, may cause an excessive demand charge for an entire month. Any practice or oversight which results in an increased demand will be disclosed by an examination of the charts of the plant power load.

It is important also to be on the lookout for unwarranted use of energy or unnecessary waste of employee time.

We find that watchful engineers are interested in knowing something about the night load, the consumption on Sunday and holidays, how long lights and motors stay on the circuit after the plant stops working, what the load is during the noon hour, how long motors are running before the time for starting work, how long it takes the whole plant to get going at full load in the morning and afternoon, and whether there is a noticeable anticipation of quitting time at noon and in the evening.

Power Factor of the Power Load

It is the practice of most power companies to include a power factor clause in the contracts with large consumers. Industries whose monthly power bills are affected by the power factor as well as the demand, want an occasional check of the overall power factor of the power load. If a power factor meter is not permanently installed, it is the usual practice to make the power factor and demand determinations at the same time.

Voltage of the Power and Lighting Service

Economical and continuous operation of an industrial plant requires that the voltage of the supply be maintained uniformly at the proper value. The ability of heavily loaded motors to start their loads and carry them continuously

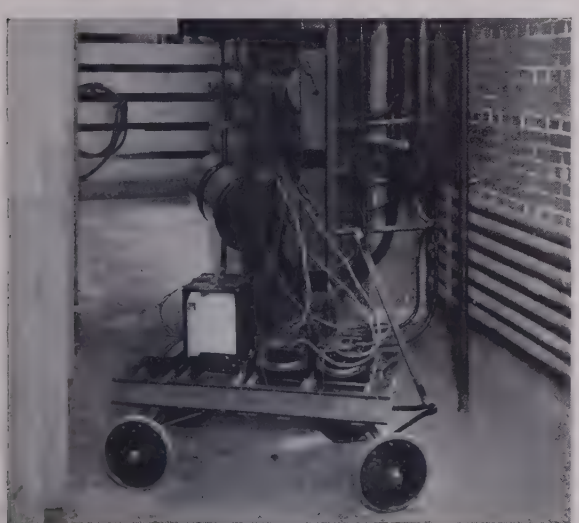


FIG. 11—*A paper company in New York uses a small wagon to carry the portable meter and the transformers from place to place. This company also has a large number of graphic meters permanently installed.*

FIG. 12—*Here is a picture of a more elaborate portable testing outfit. There is space in the cabinet below for the instruments and transformers. The set records kilowatts, volts and power factor.*

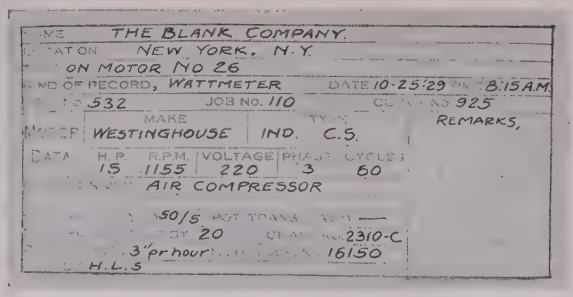


FIG. 13—*Here is a proof of a rubber stamp used by one of our customers for labeling the charts so as to identify them later.*

without overheating depends upon the voltage being kept at the proper value. The starting torque of induction motors drops off approximately as the square of the reduction in voltage. A motor which is carrying all the load it can handle at the proper voltage will quickly overheat if the voltage is appreciably lowered.

Again both the economy and life of incandescent lamps require the maintenance of a constant voltage at the proper value. A supply voltage of only two volts above the rating on the incandescent lamps reduces their life 21 per cent, while a voltage four volts below the rating reduces the illumination by 15 per cent. A regular check of the voltage at the terminals of power and lighting circuits is therefore customary in most industrial plants.

Interpreting Charts of Total Load

Now assuming that the necessary equipment has been provided, the circuits and motors numbered, let us see how engineers proceed to obtain and use the data which graphic instruments make available. Beginning with the main power circuit, the wattmeter, ammeter, power factor meter and voltmeter are connected so as to record the total load. These should be left in this circuit at least one week, so as to get representative day and night load curves, including Sunday. When the record has been obtained it should be studied to get the answers to such questions as these:

1. What is the maximum plant load in kilowatts and amperes?
2. On what day of the week did it occur?
3. Was the peak load the same for each day?
4. If not the same, why not?
5. What was the load during noon hours?
6. Was it the same each day; if not, why not?
7. What is the night load?
8. Was the night load the same each night?
9. Is there evidence of waste of power by starting equipment before hours in the morning or letting it run after the plant is supposed to shut down?
10. How does the peak load compare with the power company's demand charge for the previous month?
11. How long did it take the plant to reach full power load after starting time in the morning and afternoon?
12. Is there evidence of a tendency to anticipate quitting time at noon and in the evening?
13. What is the maximum and minimum power factor of the load?
14. When did minimum power factor occur, and how do you account for it?
15. How does the power factor compare with that on which the power bill is based?
16. What is the maximum and minimum lighting voltage at the main bus?
17. When do maximum and minimum lighting voltages occur?
18. What is the maximum and minimum power voltage at the main bus?
19. When do maximum and minimum power voltages occur?
20. What is the voltage drop between the bus and the lamps at different points in the plant?
21. What is the voltage drop between the main power bus and the different motors in the plant?
22. How does the voltage at the lamps compare with the voltage rating of the lamps used?

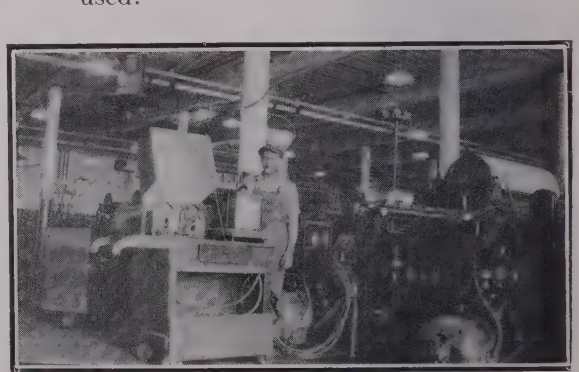


FIG. 14—*This is a picture of a survey in progress in a Georgia textile mill. This test bench is made of wood.*

CHECKING UP THE DEPARTMENTS

The next step is to secure records on the different divisions or departments of the plant, thus enabling the engineer to localize some of the causes of undesirable conditions that may be shown by the load curve of the plant as a whole.

For example, if the record of total power shows that productive effort lags in the morning and afternoon, or that quitting time is anticipated by workmen, the next step is to find in what departments this occurs. One of the advantages of graphic instruments is that this information can be obtained by placing the meters in the circuit at some remote point, and the exact conditions will be recorded without the department being aware that such a test is being made. Where group drives are used, it is a good practice to check up the friction load of each division of the plant at regular intervals. This testing must be done when the machines are not in productive use. Surprising results are often obtained.

In most instances a single day's run is sufficient for a departmental test, although things may be disclosed which will make advisable several days' run in order to see if such conditions repeat themselves. In most plants engineers use only graphic wattmeters on departmental feeders, and in many industries the information gained from such records has been of such value as to result in the installation of graphic instruments permanently in the power feeders to each department. Following is the information which usually can be obtained from the graphic records of the department:

1. Did the department start on time in the morning and at noon?
2. How long did it take for the department to reach full power load in the morning? How long after lunch?
3. To what extent was quitting time anticipated at noon and in the evening?
4. What is the friction load in the department?
5. Has the department a peak which corresponds with the total peak, and if so, what causes it?
6. Are motors started at the proper time in the morning and afternoon, and are they shut down promptly at noon and at quitting time?
7. What is the night load? The noon load?
8. Is there anything in the record which gives a clue to waste of power or of employee time?
9. What portion of the demand charge and energy consumption should be allocated to this department?
10. What is the power factor?
11. If the power factor is low are there any large induction motors that could be replaced by synchronous motors?

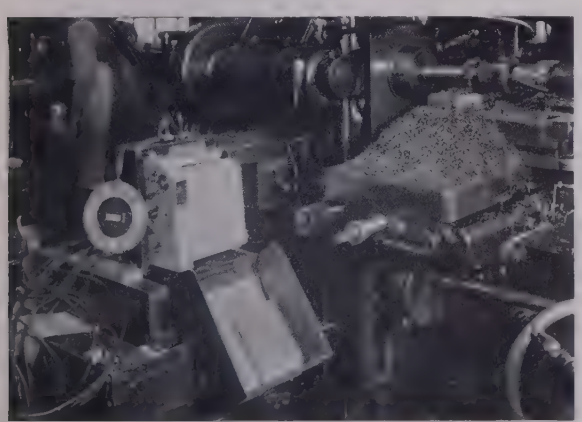


FIG. 15—*A survey in progress in a machine shop. The instrument does not in any way interfere with the progress of the work.*

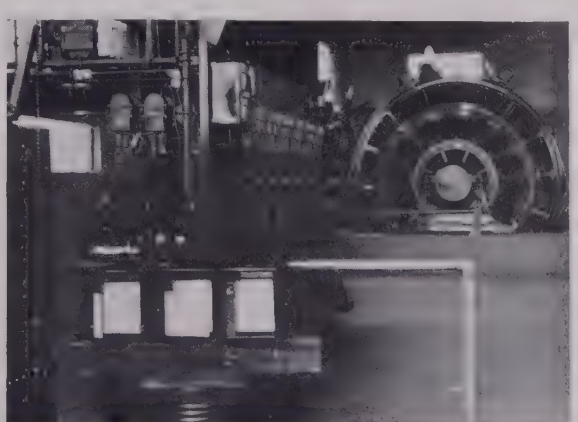


FIG. 16—*This shows a survey in progress in a coal mine. The kilowatts, amperes and power factor of the hoisting equipment are being recorded.*

CHARTING INDIVIDUAL MOTORS

When the records of total load and of the departments have been obtained, the next step is to test each individual unit in the plant. The records of total load and those of the departments give a general, overall measure of conditions, while the tests of individual units show what each piece of equipment is contributing to the total result. Correction of any faulty condition shown by the overall record can best be done by carrying out the test on the different units, as it is these which show where the remedy must be applied.

On small units, say 50 horsepower and under, most engineers use only a graphic voltmeter and wattmeter, but on units larger than this it is customary to employ an ammeter and a power factor meter in addition. In making records on individual machines the engineer should see to it that conditions are normal, and he should be on the lookout for information which may affect any one or all of the different elements of cost, and in many cases the quality of the product as well. Many engineers in making such tests for information on power conditions have discovered things bearing on labor losses, processing, condition of equipment, etc., which were of equal if not greater importance than the data they were actually seeking.

Such tests as we have described are especially illuminating in showing the performance of automatically operated equipment, such as pumps, air compressors and fans which are motor driven and automatically started and stopped. The record shows when and how long each piece of equipment is operated, and how long it was idle each day. It discloses waste if the automatic equipment is not functioning properly.

The length of time instruments should remain in the circuit of an individual machine depends altogether upon conditions. In some cases a 24-hour run is necessary; in others, a full working day, and in still others a much shorter time will suffice. With many types of load it is better to use a slower chart speed and a longer time in order to cover all conditions, and in other cases a shorter time with rapid chart speeds is a better procedure. In many instances, for example, where the motor is driving a group of machines or a line of shafting, it is well to have a portion of the record show the idle or friction load in order to discover any unusual conditions which may have developed since the last survey.

FIG. 17—*Here is another home-made test bench, used by a Cleveland manufacturer of automobile parts. This company also makes most of its time studies with graphic meters.*

The records taken in the survey of individual machines should be studied for the answers to such questions as the following:

1. If the unit is a motor, what is its rating?
2. What is the maximum, minimum and average load on the motor?
3. What is the power factor taken at the motor?
4. If the motor is overloaded, what is the horsepower of the motor that should replace it?
5. If the motor is underloaded, what size should be put in its place?

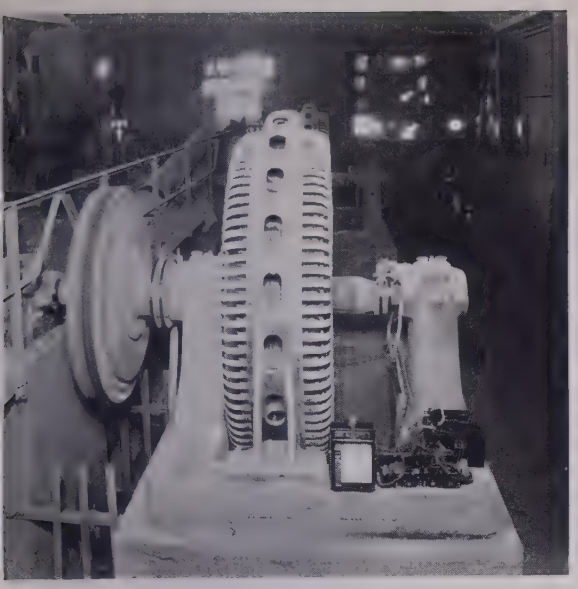


FIG. 18—*A power survey in a modern cement mill. The instrument is recording the operation of the pulverizing machinery.*

6. Is the voltage at the motor terminals the proper value?
7. How many KW does the unit contribute to the peak load?
8. Is this a unit which could be operated on "off peak" service to reduce the maximum demand?
9. Is the load on this unit one of those contributing to any loss of productive effort shown by the departmental record?
10. What is the idle or friction load of the unit?
11. Does the friction load show any marked increase since the last survey?
12. Does the record show any characteristics which indicate a faulty condition of the motor or the equipment which it drives?
13. Does the record show any unnecessary loss of time on the part of the operator of the equipment?
14. How does the character of this record compare with others taken on similar equipment in the plant?
15. Does the record disclose any important information regarding operations or processes, which is of value in reducing cost or maintaining the quality of the product?

USING THE INFORMATION

The reader will recognize at once that the information obtained by such a survey as we have described touches the interests of several departments of a modern industrial plant. Purchase or generation of power, maintenance, cost determination, engineering, production and inspection are all at times covered in the records obtained.

We know that in some plants the surveys are made by one department, usually either maintenance or engineering, and then the records with proper interpretation are made available to other departments through the medium of an efficiency committee representing all departments. A systematic study of plant operation usually discloses some faults, short-comings and oversights of men, and it is quite important to have a set-up which will obtain results without creating friction.

Report to Executives

Without question the most far-reaching results are being obtained in those plants where a complete report of each survey, with proper summary and conclusions, is placed in the hands of the management. From the executive, the head of each department touched by the report receives the decisions or instructions of the man-

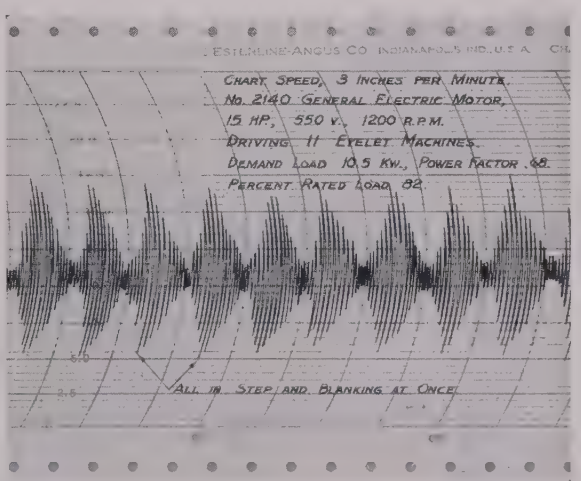
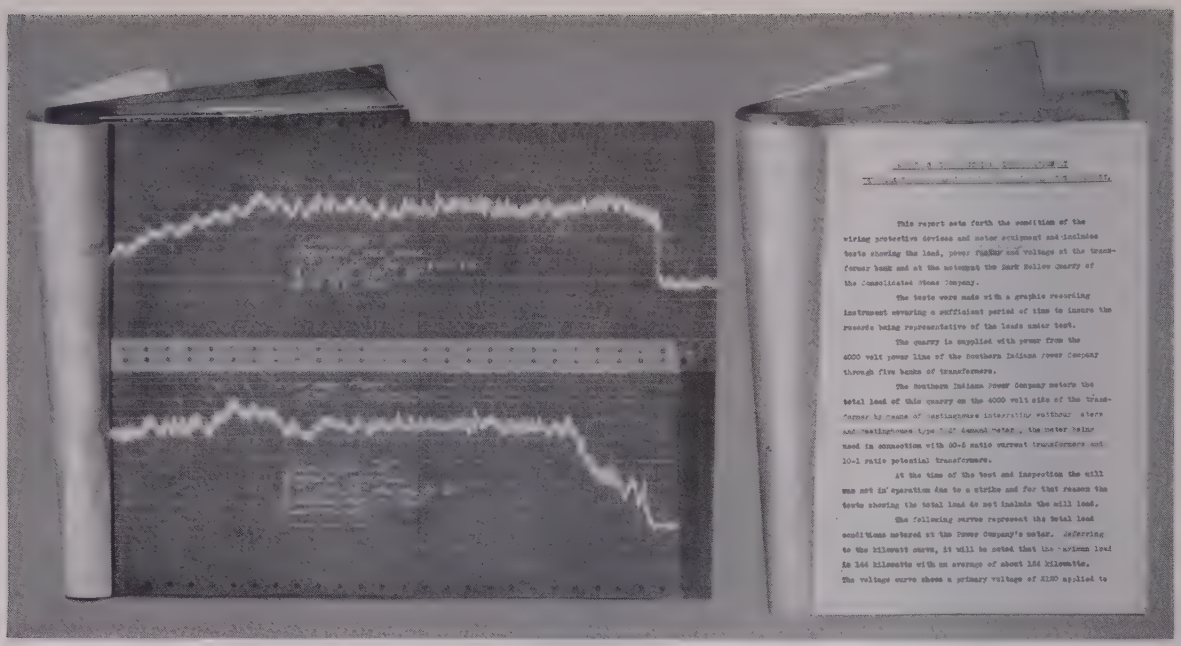

ESTELINE-ANGUS CO INDIANAPOLIS IND. U.S.A.
CHART SPEED, 3 INCHES PER MINUTE.
NO. 2140 GENERAL ELECTRIC MOTOR.
15 HP., 550 V., 1200 R.P.M.
DRIVING 11 EYELET MACHINES.
DEMAND LOAD 10.5 KW., POWER FACTOR .68.
PERCENT RATED LOAD 82.
ALL IN STEP AND BLANKING AT ONCE

FIG. 19—*Here is a chart made in a survey of a New England manufacturing plant, which disclosed that a number of group driven machines were putting an unexpected strain on the belt and bearings.*



This report sets forth the condition of the wiring protective devices and meter equipment and includes tests showing the load, power factor and voltage at the transformer bank and at the metering at the Bark Hollow Quarry of the Consolidated Stone Company.

The tests were made with a graphic recording instrument covering a sufficient period of time to insure the records being representative of the loads under test.

The quarry is supplied with power from the 4000 volt power line of the Southern Indiana Power Company through five banks of transformers.

The Southern Indiana Power Company meters the total load of this quarry on the 4000 volt side of the transformer by means of instantaneous integrating voltmeter and recording type [illegible] demand meter, the meter being used in connection with 60-5 ratio current transformers and 10-1 ratio potential transformers.

At the time of the test and inspection the mill was not in operation due to a strike and for that reason the tests showing the total load do not include the mill load.

The following curves represent the total load conditions metered at the Power Company's meter. Referring to the kilowatt curve, it will be noted that the maximum load is 144 kilowatts with an average of about 134 kilowatts. The voltage curve shows a primary voltage of 4180 applied to

FIG. 20—*Where the results of a survey are to be reviewed by others, it is often desirable to draw up a report, which will enable those who are not familiar with the details to understand the findings and the recommendations. We have prepared a sample report which will be sent upon request to those interested.*

agement and uses the report as a basis of carrying out the instructions or putting into execution the decisions based upon the report. In some plants an efficiency committee, composed of key men drawn from different departments, is appointed. The department making the survey reports its findings to this committee. This group considers each cause of inefficiency and waste and makes recommendations for the solution of each problem.

The results which are being obtained in this manner are in many instances really remarkable. In one instance more than twenty-four thousand dollars annually was cut off the power bill; in another seventy-four thousand dollars a year was saved on the pay roll. From the experiences of a number of engineers, we have drawn up a sample report, which shows the wide diversity of information that may be expected from a carefully conducted survey. A copy of this report will be sent free upon request to those who are interested in following the subject further.

Everything points to the need of increasing attention to the subject of making power and labor more productive, of decreasing waste, of making the entire plant cost-conscious. This company has specialized on this subject for over thirty years, and you have the privilege of discussing the subject with our field engineer, without incurring the slightest obligation.

THE ESTERLINE-ANGUS COMPANY, INC.

Specializing in the Manufacture of Graphic Instruments

P. O. Box 596

INDIANAPOLIS 6, INDIANA, U. S. A.

Bulletin Number 436-A

PRINTED IN U. S. A.

Field Engineers in All Principal Cities

Catalog of

ACCESSORIES AND SUPPLIES

for use with

Esterline-Angus Graphic Instruments

★

CATALOG 847AS

APPLICABLE TO ESTERLINE-ANGUS GRAPHIC

AC Ammeters	DC Ammeters	Speed Recorders
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* * *

Telemeters Contact-Making Meters

(For Instrument Descriptions, See General Catalog No. 847)

THE ESTERLINE-ANGUS COMPANY, INC.

Specializing in the Manufacture of Graphic Instruments

INDIANAPOLIS 6, INDIANA, U. S. A.

Issued Sept. 1, 1947. Supersedes 446AS and 245AS.

Accessories and Supplies for use with Graphic Instruments

● There are certain accessories and supplies used with graphic instruments for the purpose of giving them the proper capacity, or of adapting them to particular uses of the purchaser. This company furnishes such equipment which, by reason of its design and construction, is especially adapted for use with graphic meters. This equipment includes:

1. *Portable 9-Range Solid-Core Current Transformer*
2. *Portable Split-Core Current Transformers*
3. *Switchboard Current Transformers*
4. *Portable Potential Transformers*
5. *Switchboard Potential Transformers*
6. *KVA-RKVA Phase-Shifting Network*
7. *Ammeter and Wattmeter Shunts*
8. *Electrical Counters*
9. *Chart Inspector*
10. *Quick Connectors*
11. *Cable Clamps*
12. *Carrying Cases*
13. *Case Lock*
14. *Inks*
15. *Pen Filler*
16. *Inkwell Filler*
17. *Repair Parts*
18. *Charts*

9-Range, Portable Current Transformers
(Solid-Core Type)

It is no longer necessary to carry a number of portable current transformers of different sizes in order to adapt instrument ranges to different circuit capacities. Here is a metal clad, highly insulated, portable current transformer having nine primary ranges of 10, 12.5, 25, 50, 100, 160, 200, 400 and 800 amperes. Five of these ranges are obtained by means of a wound primary; the other four by looping the primary conductor through an opening in the core and case.

Esterline-Angus Universal Current Transformers are designed for use on voltages up to 2500 volts, including 4000 volt star circuits with grounded neutral. They have a volt-ampere rating of 25 VA, and are compensated for 15 VA. This high capacity makes it possible to operate several meters from the transformer at one time, without impairing the accuracy.

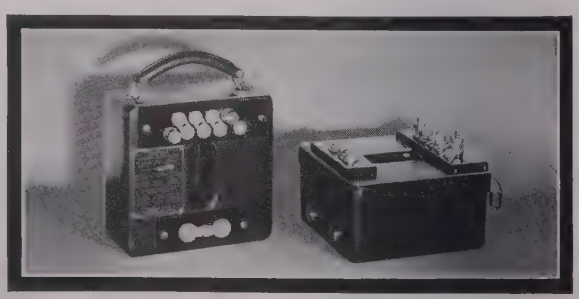
TRANSFORMER CONSTRUCTION

The transformer case is made of cast aluminum, which is not easily damaged by rough handling, heat or moisture. The core is built up of a fine grade of silicon steel and the windings thereon are insulated with mica to withstand a dry test of 9000 volts alternating current.

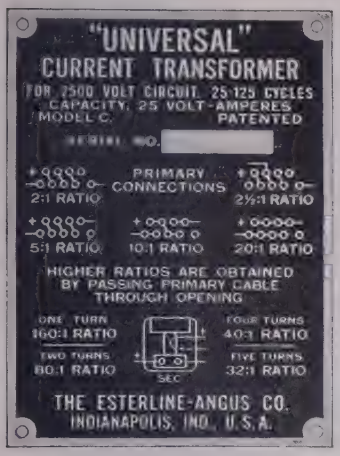
After the transformer is placed in the case, all moisture is removed from the winding and then all the remaining space is filled with hot compound which renders the transformer moisture-proof and at the same time greatly increases its insulation. The finished transformer withstands a test of 12,500 volts between primary and secondary, with the secondary grounded to the case, and 5000 volts from secondary to case. This insures adequate safety to the user. In addition, a secondary short-circuiting switch is provided.

ELECTRICAL DATA

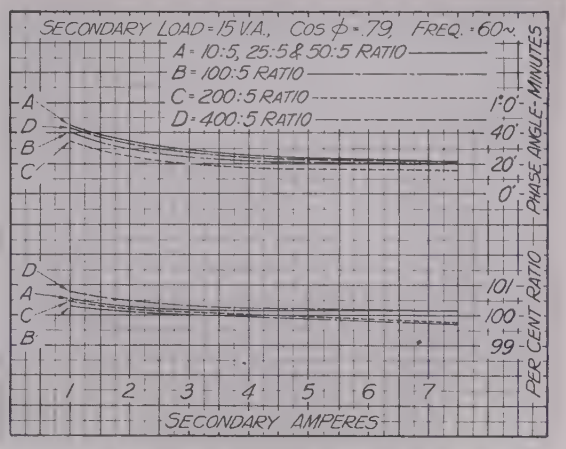
The electrical characteristics of these transformers are unusually good, both as regards phase angle and ratio. Considering the increased number of ranges, the rugged construction, the moisture-proof qualities and the excellent electrical characteristics of these transformers, we have no hesitancy in say-



A pair of portable universal current transformers.



Name plate of the Universal Current Transformer, showing how the nine primary ranges are obtained.


SECONDARY LOAD = 15 V.A., Cos φ = .79, FREQ. = 60~
A = 10:5, 25:5 & 50:5 RATIO
B = 100:5 RATIO
C = 200:5 RATIO
D = 400:5 RATIO
PHASE ANGLE-MINUTES
PER CENT RATIO
SECONDARY AMPERES

Ratio and phase-angle curves of Universal Current Transformer

ing that they stand unequalled on the market today. These transformers will carry continuous overloads of 30% on the wound primary ranges, and 70% on the through-type ranges, without overheating.

The Quick Connectors described on page 68 often greatly facilitate use of this type of current transformer.

The weight of a Universal current transformer is 28 pounds; a pair packed for shipment weighs 65 pounds.

UNIVERSAL CURRENT TRANSFORMERS

Rating	Code Word
10, 12.5, 25, 50, 100, 160, 200, 400, 800 amperes primary to 5 amperes secondary.....	YURUJ

Portable Split-Core Current Transformers

In places where it is impractical to open a circuit to permit the use of the high-accuracy closed-core current transformers described on page 62, a split-core transformer is now available for the operation of graphic wattmeters, AC ammeters and power factor meters. These transformers are made in several sizes and with ratios from 150/5 to 3000/5 amperes, single- and multi-range. All are compensated for a burden of 10 VA, 60 cycles. Correspondence is invited.

Switchboard Current Transformers

(Illustrated on page 64)

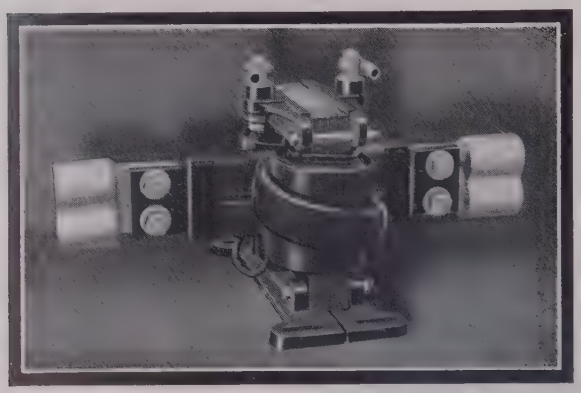
Standard switchboard current transformers are of the indoor dry type and are accurate on all commercial frequencies. Those from 10 to 800 amperes primary capacity are of the wound type and are good for a maximum voltage of 5000 and have a capacity of 50 volt amperes and a ¼Z accuracy rating.

The bus bar type is usable on voltages up to and including 2500 volts, and is available with current ratings listed below. The transformers used should be of a primary capacity which will give the instrument a range corresponding to one of the standard charts. If the current transformers are not to be furnished with the meter their primary capacities should be stated in the order for the meter.

SWITCHBOARD CURRENT TRANSFORMERS

Wound Primary Dry Type, 50 VA 5000 v. (Sangamo Type M-50)		Rectangular Bus Bar, Indoor Type 2500 volts (Westinghouse Type H-2.5)		
Primary Amperes	Code Word	Primary Amperes	Opening in Inches	Code Word
10	YUSJO	800	3⅛x1 1/16	ZIVOV
15	YUSUK	800	4⅛x ⅞	ZIVRA
20	YUSYL	1200	3⅛x1 1/16	ZIPPO
25	YUTAG	1200	4⅛x ⅞	ZIPRY
30	YUTGA	1500	3⅛x1⅞	ZIVYX
40	YUTHE	1500	4⅛x1⅜	ZIWAS
50	YUTIJ	2000	3⅛x1⅞	ZIYAT
75	YUTOK	2000	3⅛x3⅜	ZIYBD
100	YUVAH	2000	4⅛x1⅜	ZIYCF
150	YUVHA	3000	3⅛x3⅜	ZIZOZ
200	YUVIK	3000	4⅛x4⅛	ZOBAC
300	YUVJE	4000	4⅛x4⅛	ZOBUH
400	YUVLO	4000	6⅛x2 1/16	ZOCOH
600	YUVOL	5000	6⅛x2 1/16	ZIRTY
800	YUVUM	5000	4⅛x4⅛	ZIRUS
		7500*	6⅛x4½	ZIUMM
		10000*	6⅛x4½	ZIURS

*Type FB. Insulated for 600 volts only. These transformers can be split, to permit mounting without disassembly of bus structure.



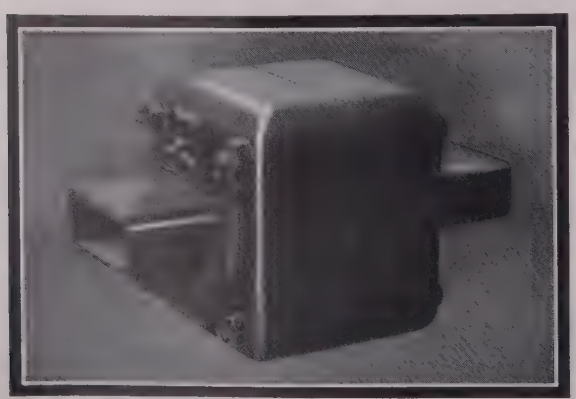
Wound type switchboard current transformer
(*See page 63*)

Portable Potential Transformers

Portable potential transformers furnished for use with Esterline-Angus instruments have capacities ranging from 7 to 120 volt-amperes, and are compensated at 2 to 30 volt-amperes, depending on the voltage and frequency. Net weight, 24 lbs. The accuracy under ordinary conditions is $\pm\frac{1}{4}\%$ in ratio and 20 minutes in phase angle. Special low voltage potential transformers are described below.

PORTABLE POTENTIAL TRANSFORMERS
(WESTINGHOUSE TYPE PV-130)

Primary Volts	Secondary Volts	Ratio	25 Cycles Code Word	60 Cycles Code Word
240/480/600	120	2/1, 4/1 and 5/1	ZIWET	ZIYEV
600/1200/2400	120	5/1, 10/1 and 20/1	ZIWUX	ZIYJL
1200/2400/4800	120	10/1, 20/1 and 40/1	.....	ZIYLN



Bus bar type switchboard current transformer
(*See page 63*)

Switchboard Potential Transformers

Switchboard potential transformers furnished with Esterline-Angus instruments have a capacity of 200 volt amperes, are compensated at 40 volt amperes and can be furnished in the ranges listed below.

SWITCHBOARD DRY TYPE—COMPENSATED 40 VA
(WESTINGHOUSE TYPE PT)

Volts Primary	Volts Secondary	Ratio	V.A. Capacity	25 Cycle Code Word	60 Cycle Code Word
240	120	2–1	200	ZAAHS	ZABNE
480	120	4–1	200	ZAAJT	ZABSY
600	120	5–1	200	ZAARD	ZABUR
2400	120	20–1	200	ZAASF	ZABYS
4800	120	40–1	200	ZAAWJ	ZACAN

Low-Voltage Double Potential Transformers and Isolating Transformers

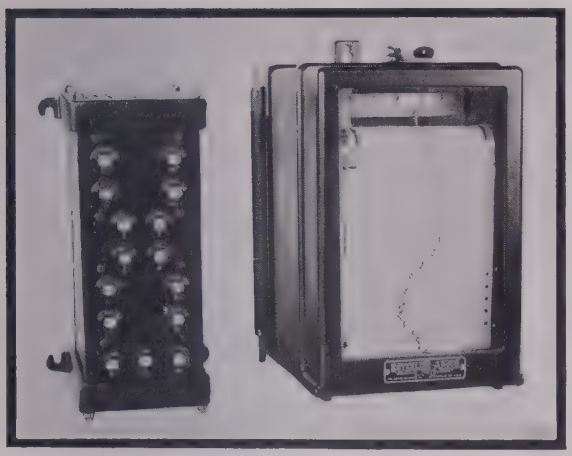
Particularly for use with the KVA-RKVA meter and network on 230- and 460-volt circuits, a special double potential transformer has been designed, consisting of two electrically separate transformers mounted in a single case, with dimensions the same as for the phasing network. Each transformer has a double voltage rating, 460/115 and 230/115 volts, 50-60 cycles. All connections are brought out to separate terminals. Each of the two transformers has a capacity of 40 VA, and is compensated for 10 VA. The complete double transformer weighs 23 pounds, and the case dimensions are 6–1/2″ x 6–1/2″ x 13–1/2″.

For use in KVA metering circuits requiring an isolated potential, a 1/1 ratio transformer is available. This transformer has a capacity of 50 VA, and is compensated for 10 VA. Case dimensions are the same as for the double potential transformer; the net weight is 14 pounds.

Both the isolating transformer and the double potential transformers may be used wherever potential transformers of the listed ratings and capacity are suitable.

POTENTIAL TRANSFORMERS

Type	Voltage Rating 50–60 Cycles	Case	Code Word
Double Pot. Transf.	230/460 to 115	Wall or Swbd.	ZIYVE
	230/460 to 115	Portable	ZIYUZ
Isolating Pot. Transf.	115/115	Wall or Swbd.	GAMUZ
	115/115	Portable	GAMVE



Complete KVA-RKVA meter, consisting of recorder and separate phase-shifting network.

KVA-RKVA Networks

PHASE SHIFTING NETWORK: The phase shifting network supplied with the KVA-RKVA Meter can be used to measure KVA or RKVA with any standard 2-element wattmeter, whether recording, indicating or integrating. This network is furnished for use up to 270 volts, 50–60 cycles, or 135 volts, 25 cycles. The wattmeter must have a potential range corresponding to the voltage of the circuit on which the combination is used. On circuits requiring a range higher than 200 volts, potential transformers must be used.

For KVA measurements the phasing network carries three sets of taps for different average power factors. The low tap covers a range of 0.52 to 0.85; the middle tap covers a range of 0.64 to 0.93; the high tap covers a range of 0.73 to 0.95. (As a special item, a network is available with an additional range of 0.90 to 1.0.)

For RKVA measurement, the high tap on the phasing network is employed, with a different method of connection. Readings are correct for any power factor.

This phasing network is for use on 3-phase circuits, either 3-wire or 4-wire. It is not operable on single phase or 2-phase AC. The network has a rated capacity of 25-volt-amperes and is compensated for 8-volt-amperes. Case dimensions are 6–1/2″ x 6–1/2″ x 13–1/2″, and the net weight is 16 pounds.

Phase shifting network for wall or switchboard mounting.....Code ZYPJA
Portable phase shifting network.....Code ZYPKE

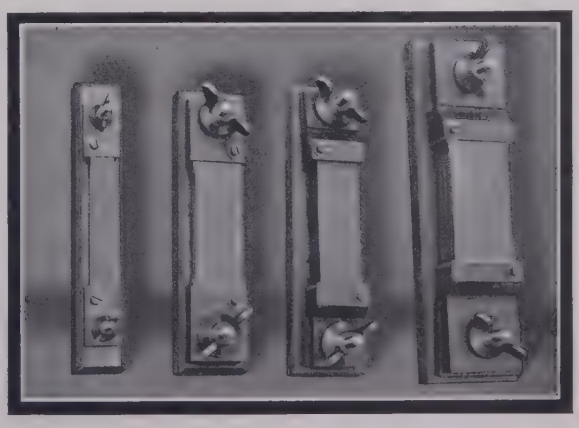
Counters

Electrically-operated counters (Veeder-Root forms UD and US) can be furnished for operation on voltages of 6, 12, 24, 55, 110, and 220 volts DC and 55, 110, and 220 volts AC, 50 to 60 cycles. The counters have five figures and can be reset to zero. The energy required to operate the counter is approximately 15 watts. The mechanism is sufficiently fast to register accurately operations occurring as rapidly as ten per second.

Ammeter and Wattmeter Shunts

Esterline-Angus shunts are of the highest type of design and construction. The lugs are of solid copper, machined accurately to size. The resistance metal has practically zero temperature coefficient, and zero thermo-electric effect against copper.

We make shunts of capacities from 1 to 30,000 amperes. Shunts of capacity from 10 to 10,000 amperes are standard, larger shunts usually being special. For large currents, particularly above 10,000 amperes, it is often most economical to use two or three



Portable ammeter and wattmeter shunts.

smaller identical shunts in parallel. The maximum capacity in the portable type is 5,000 amperes. Portable shunts are mounted on insulating bases.

Unless otherwise specified, shunts are of 100 millivolt drop at rated current. In ordering it is necessary to state whether shunts are for use with recording direct current ammeters, two-wire wattmeters, or three-wire wattmeters. In ordering shunts for use with instruments already in service, the serial number of the instrument must also be given. In ordering shunts for use with indicating or integrating instruments, the make and model numbers of the instrument, or its full scale current consumption, must be given.

The dimensions of standard shunts from 10 amperes to 10,000 amperes capacity are given on page 67. The lower illustration shows the standard bus-bar slotting employed on shunts of 2,500 amperes and larger. Other slottings are special and should be made the subject of correspondence.

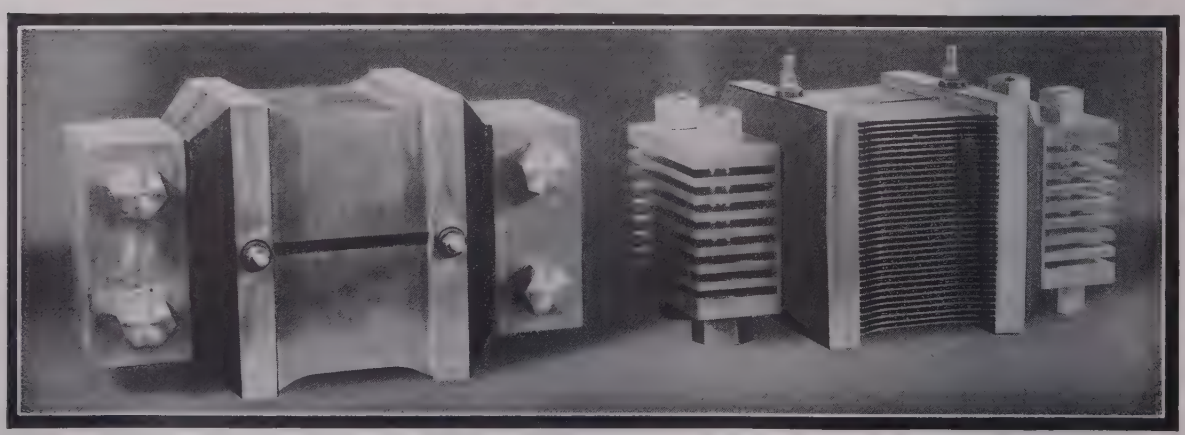
Large shunts (especially those of capacity greater than 5000 amperes) should always be installed with at least 3 feet of unbroken bus on each side. The blades should be vertical and there should be free access of air all around the shunt. There should be no heat-producing devices (such as other shunts) in close proximity.

Esterline-Angus shunts are guaranteed to ½% accuracy. In calibration, allowance must be made for the current taken by the meter in the case of recording ammeter shunts up to and including 50 amperes capacity, three-wire wattmeter shunts up to 1,000 amperes, and two-wire wattmeter shunts up to 2,000 amperes capacity.

D. C. AMMETER AND WATTMETER SHUNTS

Ampere Capacity	SWITCHBOARD TYPE	PORTABLE TYPE
	Code Word*	Code Word*
10†	YUKZO	YUODS
25	YULBO	YUOFT
50	YULIZ	YUOWM
100	YULOB	YUPAB
150	YULUC	YUPBA
200	YULWA	YUPCE
250	YULYE	YUPEC
300	YUMAY	YUPFO
400	YUMCO	YUPID
500	YUMEZ	YUPOF
750	YUMIB	YUPUG
1000	YUMOC	YUPYH
1500	YUMUD	YURAD
2000	YUMYA	YURDA
2500	YUMZE	YUREF
3000	YUNAZ	YURFE
4000	YUNBE	YURHO
5000	YUNDO	YURIG
6000	YUNEB	.....
8000	YUNGY	.....
10000	YUNIC	.....

*Add code word ZATOK to designate 2-wire wattmeter shunt, code ZATUL for 3-wire wattmeter shunt, or code AWDIC for ammeter shunt.
†2-wire wattmeter shunt not furnished with rating of 10 amperes or less, inasmuch as meter current circuit normally requires 10 amperes.



Esterline-Angus shunts are liberally designed and accurately made. This illustration shows a pair of 10,000 ampere shunts.

Dimensions of Switchboard Type Shunts

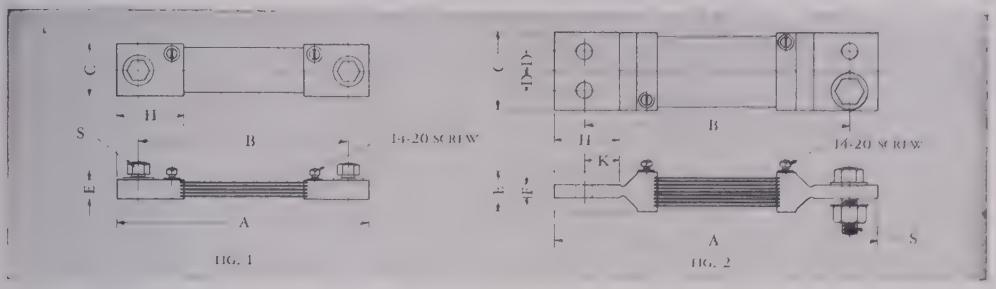


FIG. 1 FIG. 2

Amperes at 100 Milli-volts	Figure No.	DIMENSIONS IN INCHES									Approx. Weight in Pounds
		A	B	C	D	E	F	H	K	S-Size	
10–25–50	1	8½	7 3/8	1¼	...	¾	...	2	...	1/8	½
100–150	1	9	7 7/8	1½	...	½	...	2¼	...	1/8	1¼
200–250–300	1	9½	7 7/8	2	...	¾	...	2½	...	½	2¾
400–500	2	10	8¾	2	*	1 1/16	¾	1½	⅞	½ x 1¼	3
750–1000	2	12¼	10	3	¾	1½	½	2½	1⅜	¾ x 2	7
1500–2000	2	13¾	11⅛	3½	⅛	2⅜	⅝	3	1 1/16	¾ x 2¼	12

*400 and 500 Ampere shunts have only one hole in each end.

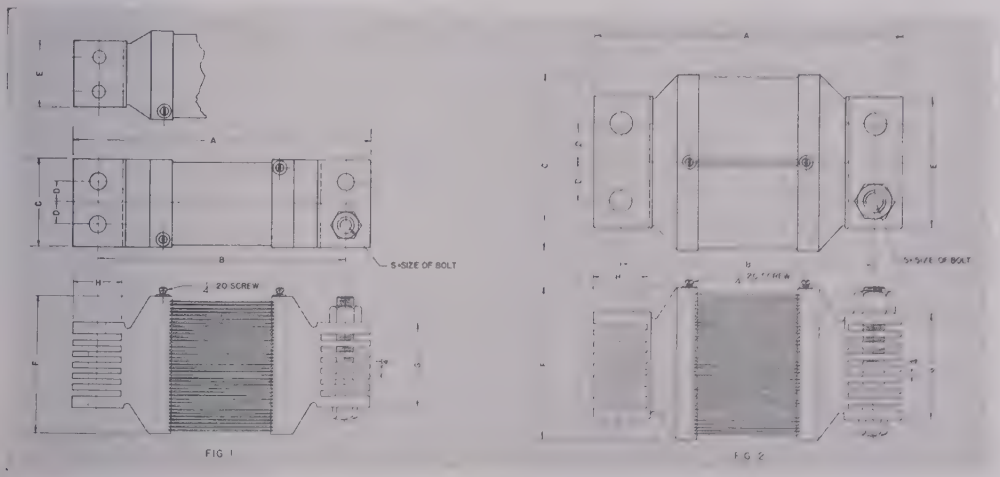


FIG. 1 FIG. 2

¼" Slots, ¼" Spacing—Special Slotting on Request

Amperes at 100 Milli-volts	Figure No.	Number of Slots	DIMENSIONS IN INCHES									Approx. Weight in Pounds
			A	B	C	D	E	F	G	H	S-Size	
2500	1	4	13	11	4	¾	3	3¼†	2 3/16	2	½ x 3½	25
3000 and 4000	1	5	13½	11¼	4	1	...	5	3¼	2¼	¾ x 4	43
5000	1	6	13½	11¼	4	1	...	6¼	3 7/8	2¼	¾ x 5	55
6000	2	6	13½	11¼	8	1⅜	5	4½†	3¾	2¼	¾ x 5	90
8000	2	8	13½	11¼	8	1⅜	5	5½†	4 7/8	2¼	¾ x 6	105
10000	2	8	14	11½	8	1¾	6	7	4 7/8	2½	1 x 6	118

†NOTE: On these shunts, over-all height is determined by cap screw "S"

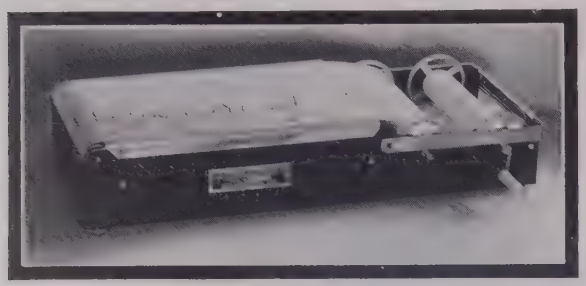


Chart inspector for reviewing records made by graphic instruments.

Chart Inspector

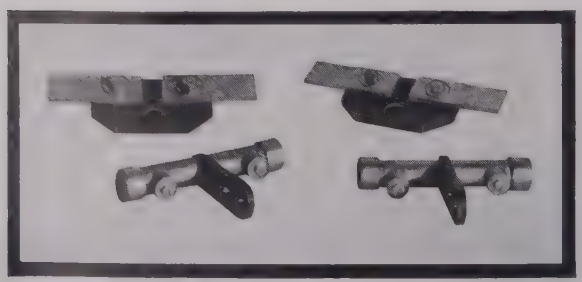
It is frequently desired to examine a completed record chart to make observations and obtain data. For this purpose, we furnish a neat metal case provided with a chart roller which is rotated by a small crank.

The chart to be inspected is placed on a roller and as the crank is turned, the chart moves across a flat table in front of the operator. When the operation has been completed, the chart is again ready for filing.

Chart Inspector.....Code Word WYDUJ

Quick Connectors

In using portable instruments about plants and buildings, considerable time can be saved by the use of quick connectors, which are made in various sizes to fit standard enclosed fuse cutouts. The fuses are simply removed and the quick connectors put in their place so as to include the instrument, current transformer or shunt in the circuit.



Quick connectors for cutting an instrument into a circuit at a fuse block.

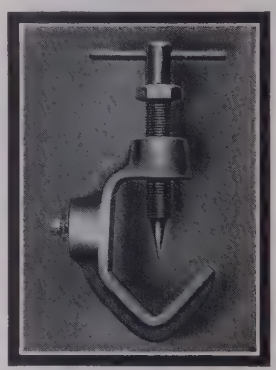
These connectors are made in two types—ferrule and knife—in five capacities ranging from 60 to 600 amperes, as listed below. The number of connectors required is equal to the number of current transformers or shunts used simultaneously.

QUICK CONNECTORS

No.	Type	Fuse Block Size		Code Word
		Amperes	Volts	
F-22	FERRULE	60	250	WYGGA
K-21	KNIFE	100	250	WYGHE
K-22	KNIFE	200	250	WYGIJ
K-23	KNIFE	400	250	WYGKO
K-24	KNIFE	600	250	WYGOK
F-62	FERRULE	60	600	WYHHA
K-61	KNIFE	100	600	WYHIK
K-62	KNIFE	200	600	WYHJE
K-63	KNIFE	400	600	WYHLO
K-64	KNIFE	600	600	WYHOL

NOTE—For insertion in standard fuse blocks.

Clamp for connecting potential leads to insulated wires.



Cable Clamps

For convenience in connecting the potential circuits of instruments to insulated cables, cable connectors are furnished. These consist of a bronze yoke with a hardened steel screw and point which will pierce the insulation, make an electrical contact and hold the clamp in place. These cable connectors are made in three sizes for different diameters of cable, as listed below.

CABLE CLAMPS

No.	Maximum Diameter of Cable	Code Word
C-11	½ inch	WYIJL
C-22	1 inch	WYILN
C-33	1½ inch	WYIRT

Carrying case for portable graphic instruments.

Carrying Cases

Many engineers prefer to take their instruments along with them, especially when traveling by motor car. For convenience in handling, and to protect the instrument, we are prepared to furnish carrying cases as shown in the accompanying illustration. These are made of black fibre, with hinged lid, carrying handle and shoulder strap. The case is reinforced with metal corners and clasps. It is lined on the inside to prevent marring the meter case. When ordering cases, the serial number of the instrument should be given.

CARRYING CASES FOR PORTABLE METERS

	Code Word
Carrying case for meter with or without standard attached multiplier	COHYO
Carrying case for meter with external motor, or with large multiplier, or with two standard multipliers	COIFT

Locks and Keys for Instrument Cases

All Esterline-Angus instruments (except those in flush cases) are provided with eccentric clamps which hold the cover closed, with provision for inserting a padlock so that the instrument case can be locked. Where instruments are left for operation in outlying districts or on the premises of another party, it is frequently desirable to lock the case, so that the meter and the record cannot be tampered with. Padlocks and keys are not furnished regularly, but constitute an extra which can be furnished if desired. All flush cases are regularly provided with a lock, built into the case door.

Padlock and Keys..... Code word WYJAJ

Ink for Graphic Instruments

To few of its products has The Esterline-Angus Company given more study and attention than to the ink supplied for use in graphic instruments. The manufacture of a superior ink for meters of this type has not been a simple problem, largely because the requirements are so conflicting. The ink must not evaporate rapidly in the inkwell, yet it should be absorbed quickly on the chart so it will not blot.

It should have sufficient body to make a clear record and to blueprint well, yet it must flow freely and not clog a fine-pointed pen. In spite of the fact that many instruments are used in places where the tempera-

Esterline-Angus ink made especially for graphic instruments.

tures are quite high, the ink must not leave an insoluble residue in the well, which later might clog the pen. Other instruments are used where the temperatures get extremely low at times.

Despite these varied and contradictory requirements, we have after years of careful research been able to produce an ink which satisfactorily meets these demands. The ingredients and the process of manufacture are carefully controlled. Special equipment has been designed and built so as to keep the processes and the product uniform.

Esterline-Angus ink is supplied in two standard colors, red and green. By mixing these two colors, a third (nearly black) may be produced. Ink is put up in two standard sizes of containers, two-ounce and pint bottles. The standard red ink produces records which will blueprint satisfactorily under most conditions. Where the standard red ink does not have sufficient opacity, as may be the case in records made at high chart speeds, a special blueprinting ink is available. In situations where the temperature is high the ink can be diluted with pure water. Where it must be used in cold rooms or out of doors in winter, it should be diluted with alcohol.

GRAPHIC METER INK

Red, two-ounce bottle	Code word	WUYLJ
" pint bottle	" "	WUYMK
Green, two-ounce bottle	" "	WUYPA
" pint bottle	" "	WUYSO

Pen Filler

When a new instrument is put in service, or when the pen tube has been cleaned, it is necessary to fill it with ink. To facilitate this process, the pen filler shown in the illustration at the top of page 71 has been developed. It consists of a compressible rubber bulb joined to a hollow soft rubber pad, having a small hole in the top. By compressing the bulb and letting it expand while the point of the pen is pressed into the small opening, ink is drawn into the pen tube and pen.

Pen Filler.....Code Word WYJIL

Ink and inkwell filler.

Inkwell Filler

For use in transfering ink from the bottle to the inkwell, an inkwell filler is used. This consists of a compressible rubber bulb and a glass tube. The neck of the bulb is made to fit the opening in a two-ounce bottle, so that the filler may be used as a stopper. This keeps the filler tube clean and prevents it from becoming lost.

Inkwell Filler.....Code Word WYJJA

Pen Element

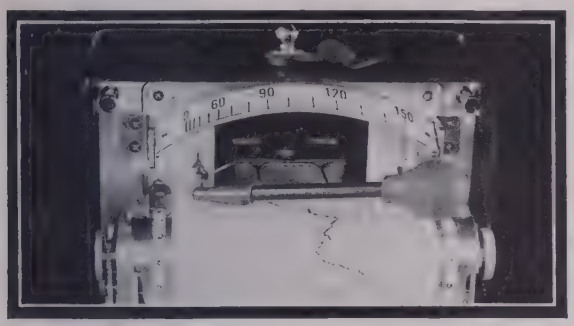
A complete element for the model A.W. meter is shown in the illustration on page 71. This element does not fit previous models.

Pen elements are shipped to balance properly when the tube is completely filled with ink. Do not change the position of the balance weights until the element has been filled and tried. If after being filled it appears to be out of balance, it is quite probable that there are air bubbles in the tube.

Pen Element for all A.W. meters except operation recorders.....Code word WYDAD
Pen Element for Model A.W. operation recorders with serial numbers below 30782. Code word WYDDA
Pen Element for Model A.W. operation recorders with serial numbers above 30782. Code word WYDEF

Removable Glass Pens

The pens used in Esterline-Angus instruments are the same for all models from the



This pen filler simplifies filling the pen and pen tube.

Glass pens and capsule in which they are shipped.

earliest to the latest. They are drawn from a special grade of glass. There are a number of advantages in the use of pens made of this material. Being transparent, it is easy to tell whether the pen is inked. The bore of the pen is tapered, and it is possible to increase the weight of the line drawn by honing the pen point. The friction on the chart is a minimum.

Glass Pens.....Code word WYBUG

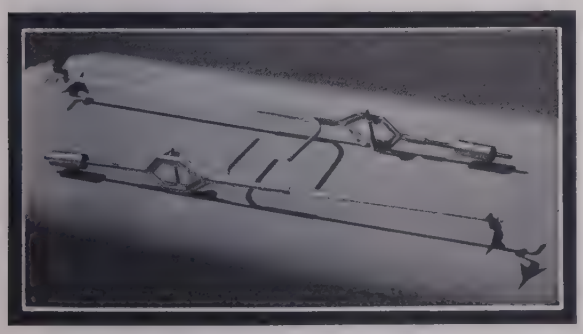
Crank for Winding Clocks

With every new type A.W. instrument, a crank for winding the clock (or reroll) is furnished. If additional ones are desired they may be ordered according to the following:

Clock Winding Crank for A. W. Meters....Code word WYEIK

REPAIR PARTS

Graphic instruments are used for many important purposes, requiring that they be kept in service continuously to avoid breaking the continuity of the records. The model A.W. meter has been designed with this in mind.



Pen element used in all Model A.W. meters (except operation recorders).

Extra Units

A company having a number of these instruments in service can insure continuity of operation by providing a few spare units. The pen elements, the escapement and spring barrel for spring clocks, and the synchronous motors for synchronous clocks are interchangeable with all other similar units, and can be quickly replaced. An extra complete chart drive, which will fit any instrument of this model, can be kept on hand to replace one requiring repair. Every user of a number of instruments should also carry in stock a few extra glass pens and a small bottle of clock oil.

Unit Exchange Service

In the past, the inconvenience of removing an entire instrument in order to effect some minor repair or adjustment has been unavoidable. This is overcome in the model A.W. instrument, by the use of the interchangeable unit construction. A company doing its own repairing and adjusting can carry these units ready for use. For those who wish to do no more than take out the unit that may require adjustment and put in another, we maintain an exchange service. All that is necessary is to remove the unit, send it to us, and in exchange we will send one ready to use.

Charts for Graphic Instruments

● As graphic instruments have come to be used in large numbers, stability in the matter of record chart design becomes increasingly important. In the use of Esterline-Angus instruments of different models, the customer is not required to carry in stock record charts of different sizes. Although new models of instruments have been perfected from time to time, the record charts can be used interchangeably in all models, from the first to the latest. This is a matter of extreme importance where a large number of instruments are in use.

Perhaps no other article manufactured by this company has received so much attention and been the subject of as much research as the record charts and the ink used in Esterline-Angus graphic instruments. It is a fact that the successful performance of the instrument depends to a large degree upon these two important supplies.

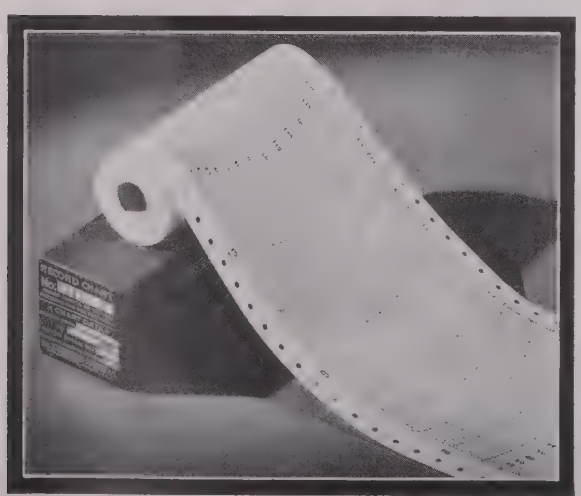
CHART QUALITY

A graphic instrument can be no more accurate than its chart. The paper of which the charts are made must be of a quality which will take ink that will not dry up in the ink-well, but will permit rerolling the chart shortly after the record is made. Various qualities of paper are affected more or less by the humidity of the atmosphere. Of charts printed at the same time, one may be required to operate successfully on an ocean liner near the equator, where it rains every few hours, and the other in a furnace room where the temperature is high and the air very dry.

Record charts made by this company are of a special grade of paper, manufactured exclusively for us, having the desired ink-absorbing qualities and the minimum change of dimensions with changes in humidity.

All standard charts are printed in two colors of special ink which does not interfere with the record being drawn by the recorder pen. Longitudinal rulings are in brown ink, with all other printing, such as range numbers, and time numbers, in contrasting blue ink.

Special equipment has been designed and built for the production of the charts so as to maintain an accurate relation between the range lines on which the values are recorded and the perforations which guide the chart as it passes through the instrument. The paper is manufactured in quantities, shipped to our plant and thoroughly seasoned before it is used. It is of a quality which can be preserved for years after the records have been made on it.



All charts are printed in two colors, and are shipped in substantial boxes suitable for filing.

DIMENSIONS AND WEIGHTS

All charts are 6 inches wide, the ruled portion of standard charts extending over a width of 4–1/2 inches, and have perforations at 1/2-inch intervals along each edge. Each chart is 103 feet long, the useful length being 100 feet; 3 feet is allowed for threading up the recorder. Range numbers are printed across the chart every 9 inches, and the time numbers along the left hand margin at intervals of 3 or 6 inches.

The weight of record charts packed for shipment is approximately 6/10 pound each. Express or parcel post shipment is suggested for quantities of less than 50 charts.

Designation of Charts

Each different range, ruling and speed of chart is designated by a number which is a combination of four or five figures and a letter (e.g., 1310-A, 43192C). The first two figures denote the type of ruling, the other figures denote the range, and the letter indicates the chart speed. This identifying number is printed at 3-foot intervals along the chart margin and is also stamped on the box in which the chart is packed.

The designations for chart speed are as follows:

¾ inch per hour—A
1½ inches per hour—B
3 inches per hour—C
6 inches per hour—D
12 inches per hour—E
no time marks —X

The minimum length of time that a chart will run at each of the standard speeds is shown in the following table:

MINIMUM RUNNING TIME OF CHARTS

Speed Inches per Hour	Feet Used Per Day	Feet Used Per Week	*Minimum Running Time in Days
A— ¾	1½	10½	65⅔
B—1½	3	21	32⅓
C—3	6	42	15⅔
D—6	12	84	7⅓
E—12	24	168	3⅔

Speed Inches per Min.	Feet Used Per Hour	Feet Used Per Day	Minimum Running Time in Hours
¾	3¾	90	26⅔
1½	7½	180	13⅓
3	15	360	6⅔
6	30	720	3⅓

*Actual running time may exceed the above minimum, depending upon starting time.

Ordering Charts

Charts should always be ordered by number or by code word, being careful to include the suffix letter which designates the speed. If in doubt, refer to the last chart taken from the meter, or give the meter serial number, chart range and chart speed.

Charts supplied without time markings are designated by the suffix letter "X." Such charts are used on intermittently-operated meters, or meters running only at minute or second speeds.

For special purposes, some users prefer a perforated chart paper containing no printing of any kind. Such paper is designated by the number "1000-X." Use this number when ordering.

If a permanently-installed meter must have a scale which does not correspond to a standard chart, usually a chart of some different range can be employed, together with an appropriate multiplying factor. If possible, the multiplying factor should be 2, 10 or 100, or ½, 0.1 or 0.01. (Factors of 1000 or 0.001 can also be used but are seldom necessary inasmuch as it is usually more convenient to change units, e.g., kilowatts to megawatts, amperes to milliamperes, etc.) On portable meters, and other meters having odd or multiple ranges, it is usually most convenient to use a chart with a range of 0–1, and then multiply the chart readings by the "constant" applying to any given set-up. Where the range is such that no simple factor is possible, charts without range numbers may be used. Such charts are available in all standard rulings and feeds and are found at the beginning of each list in the following pages.

Stock Charts

Over 800 types of charts are in stock at our factory at all times, and most chart orders can be filled within one working day of receipt of order. The most popular chart speed is 3″ per hour and charts for this speed are stocked in nearly all listed ranges.

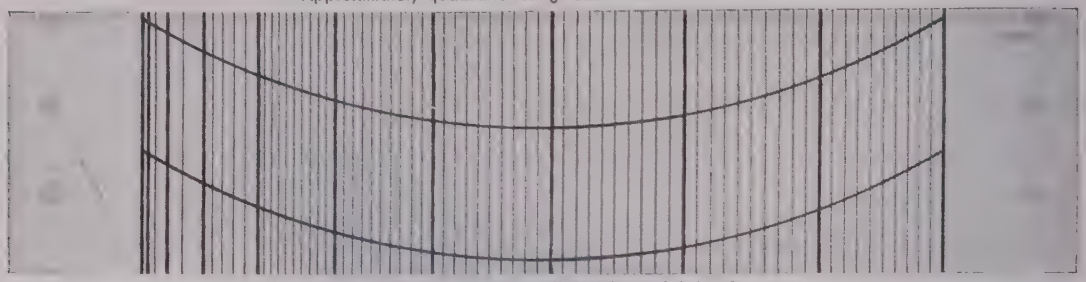
It is impractical to carry in stock every possible combination of ruling, range and speed. On infrequently-ordered combinations not carried in stock, we request that a minimum of 12 charts be ordered.

Special Charts

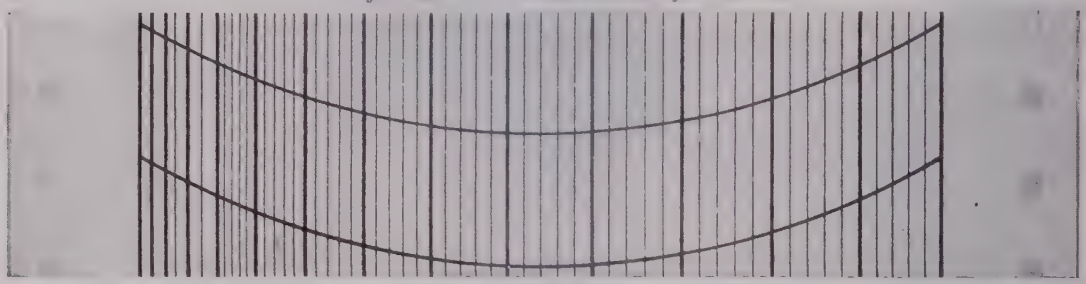
We print a great many special charts to meet the requirements of individual customers, special applications, or special meters. These charts are not listed in this catalog. In many cases, a customer's requirements can be fulfilled by an unlisted chart for which we have tools available. We will gladly quote on and send samples of such charts, and will also quote on any special charts printable on our machinery (this requires that the chart be 6 inches wide and have the same size and spacing of perforations as our standard charts) on receipt of full details of the chart design.

Charts for Model AW, LR, MS and EB AC Ammeters and AC and Utility Voltmeters

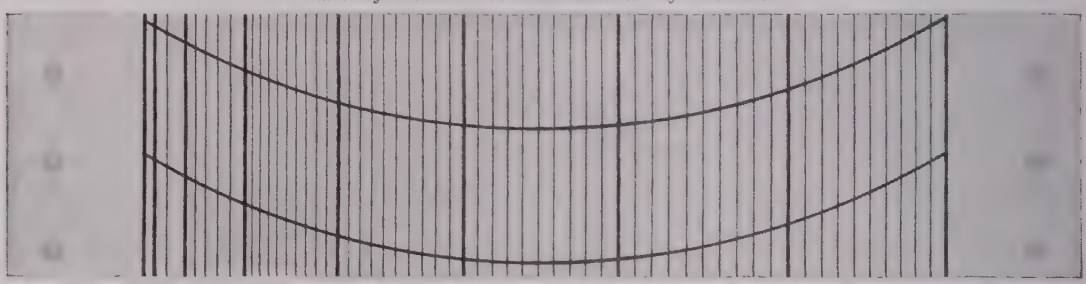
Approximately quadratic ruling. Charts shown actual size.



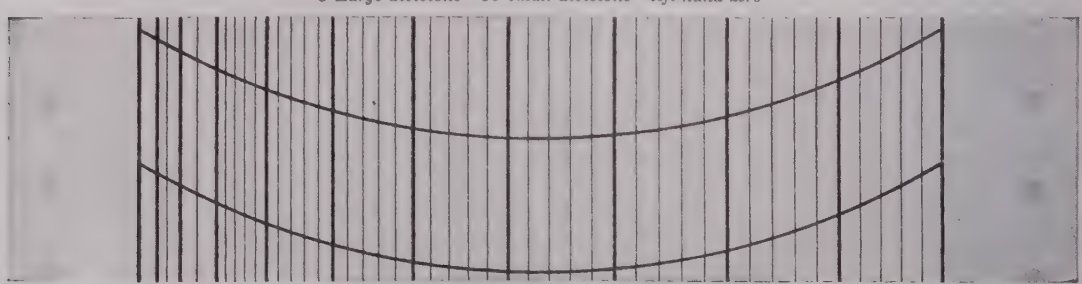
10 Large divisions—100 small divisions—left-hand zero



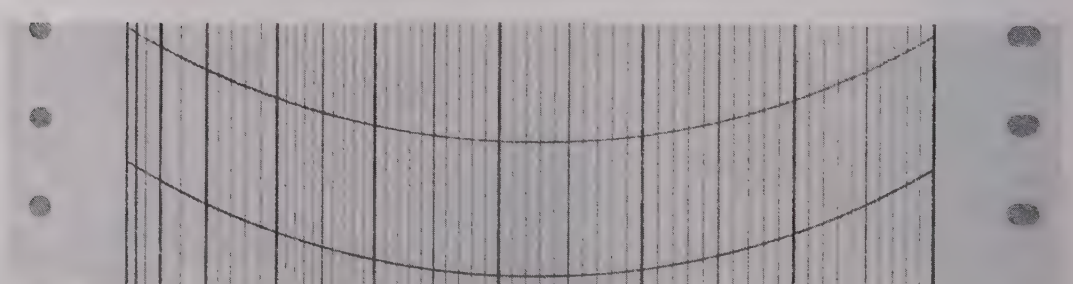
15 Large divisions—75 small divisions—left-hand zero



8 Large divisions—80 small divisions—left-hand zero



12 Large divisions—60 small divisions—left-hand zero



9 Large divisions—90 small divisions—left-hand zero

Charts for Model AW, LR, MS and EB AC Ammeters and AC and Utility Voltmeters

Approximately quadratic ruling.

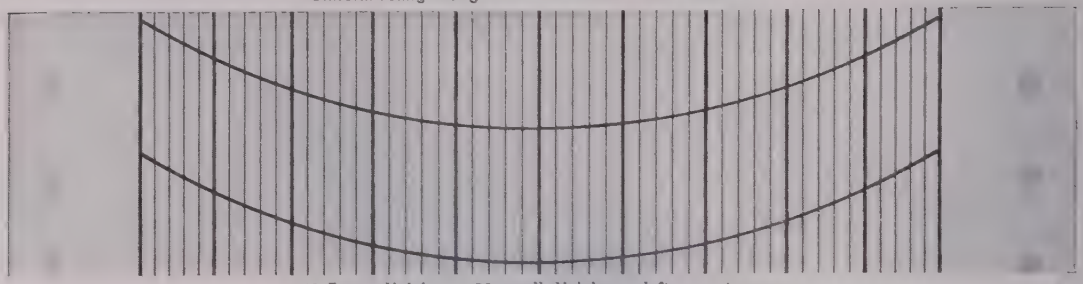
Due to the quadratic characteristics of these chart scales, it is not feasible to include in the extreme left hand portions (below approximately 10% to 15% of the scale width) the full number of large and small division ruling lines indicated in the table below. See facsimile rulings on page 74.

Chart Number†	Former Chart No.	Chart Range	Code Word†	Number Large Divisions	Number Small Divisions	Value One Large Division	Value One Small Division
1000	.....	Blank	WYLL	.....	.....	.....	.....
1300	.....	Blank	WYJM	10	100	.....	.....
1301	.....	Blank	WYKA	15	75	.....	.....
1302	.....	Blank	WYKK	8	80	.....	.....
1303	.....	Blank	WYKL	12	60	.....	.....
1307	.....	0–2½	WYTA	10	100	0.25	.025
1310	.....	0–5	WYKE	10	100	0.5	.05
1311	.....	0–10	WYKN	10	100	1.	.1
1312	.....	0–15	WYKO	15	75	1.	.2
13122	1312½	0–20	WYRA	8	80	2.5	.25
1313	.....	0–25	WYKU	10	100	2.5	.25
13132	1313½	0–30	WYLA	12	60	2.5	.5
1314	.....	0–50	WYLE	10	100	5.	.5
13141	1314¼	0–60	WYLM	12	60	5.	1.0
13142	1314½	0–75	WYLO	15	75	5.	1.0
1315	.....	0–100	WYLP	10	100	10.	1.0
1316	.....	0–150	WYMA	15	75	10.	2.0
1317	.....	0–200	WYME	8	80	25.	2.5
1318	.....	0–250	WYMI	10	100	25.	2.5
1319	.....	0–300	WYMM	12	60	25.	5.0
13192	1319½	0–400	WYMN	8	80	50.	5.0
1320	.....	0–500	WYMU	10	100	50.	5.0
13202	1320½	0–600	WYNN	12	60	50.	10.0
1321	.....	0–750	WYNO	15	75	50.	10.0
1334	.....	0–800	WYZA	8	80	100.	10.0
1322	.....	0–1000	WYNP	10	100	100.	10.0
13222	.....	0–1200	WYUC	12	60	100.	20.0
1323	.....	0–1500	WYNR	15	75	100.	20.0
1324	.....	0–2000	WYNU	8	80	250.	25.0
13242	1324½	0–2500	WYSE	10	100	250.	25.0
1325	.....	0–3000	WYOH	12	60	250.	50.0
1326	.....	0–4000	WYOJ	8	80	500.	50.0
1327	.....	0–5000	WYOL	10	100	500.	50.0
13272	1327½	0–6000	WYOP	12	60	500.	100.0
1328	.....	0–7500	WYOR	15	75	500.	100.0
1337	.....	0–9000	WYZB	9	90	1000.	100.0
1329	.....	0–10000	WYOV	10	100	1000.	100.0
1330	.....	0–15000	WYOW	15	75	1000.	200.0
13302	1330½	0–18000	WYNA	9	90	2000.	200.0
1331	.....	0–20000	WYOZ	8	80	2505.	250.0
1339	.....	0–45000	WYZD	9	90	5000.	500.0
1333	.....	0–50000	WYPA	10	100	5000.	500.0
1341	.....	0–90000	WYZE	9	90	10000.	1000.0

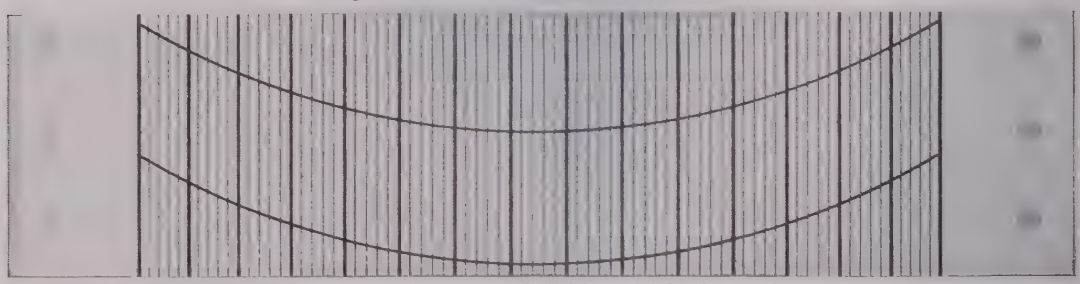
†When ordering, speed designating letter must be added; see page 73.

Charts for Model AW, LR, MS and EB DC Ammeters and DC Voltmeters, Speed and Pressure Recorders, KVA Meters and Model AW Wattmeters and RKVA Meters

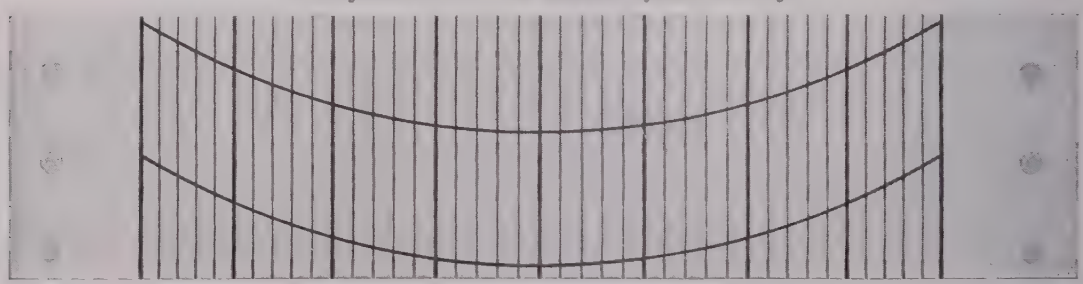
Uniform ruling along the arcs. Charts shown actual size.



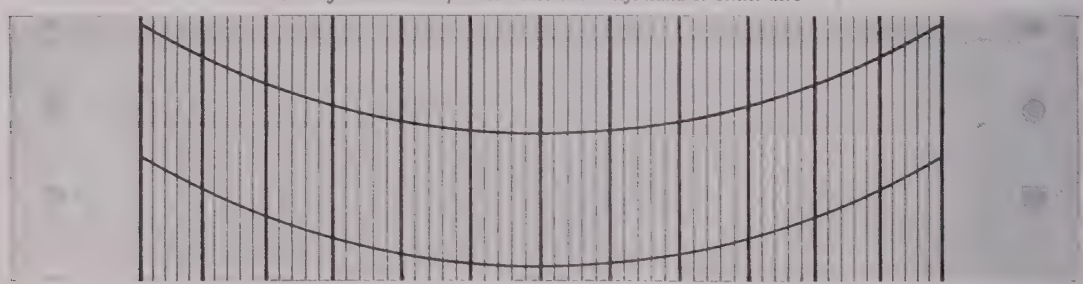
10 Large divisions—50 small divisions—left or center zero



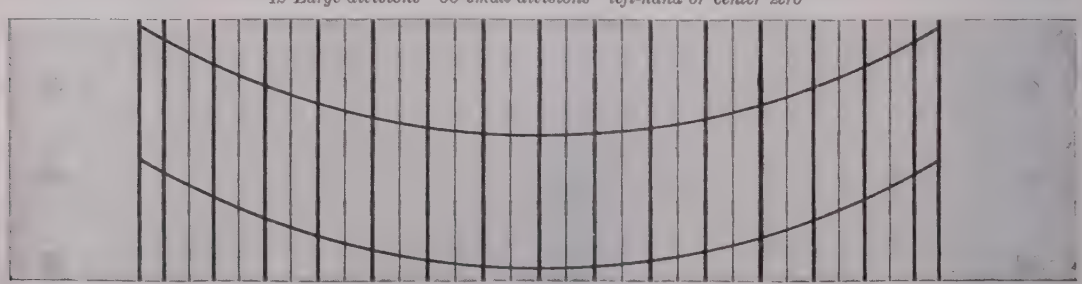
15 Large divisions—75 small divisions—left-hand zero only



8 Large divisions—40 small divisions—left-hand or center zero



12 Large divisions—60 small divisions—left-hand or center zero



15 Large divisions—30 small divisions—center zero only

Charts for Model AW, LR, MS and EB DC Ammeters and DC Voltmeters, Speed and Pressure Recorders, KVA Meters and Model AW Wattmeters and RKVA Meters

Uniform ruling along the arcs.

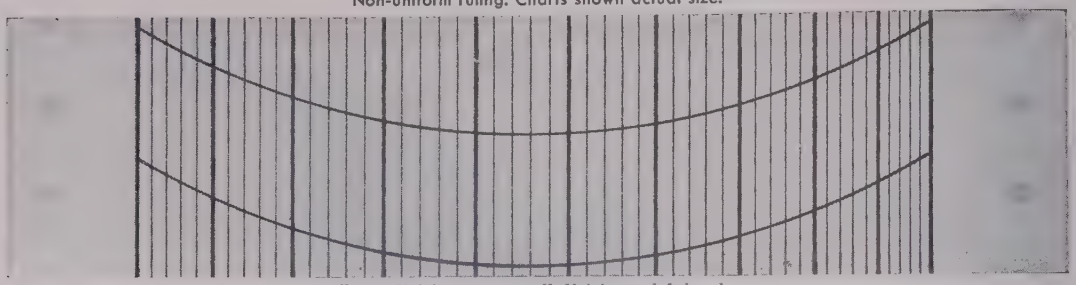
Chart Number†	Former Chart No.	Chart Range	Code Word†	Number Large Divisions	Number Small Divisions	Value One Large Division	Value One Small Division
1000	.....	Blank	WVLL	.....	.....	.....	.....
4300	.....	Blank	YAFU	10	50	.....	.....
4302	.....	Blank	YAFW	15	75	.....	.....
43022	4302½	Blank	YAEC	18	90	.....	.....
4303	.....	Blank	YAFI	8	40	.....	.....
4304	.....	Blank	YAFO	12	60	.....	.....
4305	.....	0-1	YAGI	10	50	0.1	0.02
43052	4305½	0-1.5	YAGB	15	75	0.1	0.02
4306	.....	0-2	YAGO	8	40	0.25	0.05
43061	4306¼	0-2.5	YAGU	10	50	0.25	0.05
43062	4306½	0-3	YANC	12	60	0.25	0.05
43065	4306⅝	0-4	YAGW	8	40	0.5	0.1
4309	.....	0-5	YAGV	10	50	0.5	0.1
43091	4309¼	0-6	YASO	12	60	0.5	0.1
43092	4309½	0-7.5	YAIB	15	75	0.5	0.1
4310	.....	0-10	YAHI	10	50	1.	0.2
43102	4310½	0-15	YAHO	15	75	1.	0.2
43105	4310⅝	0-20	YAHU	8	40	2.5	0.5
4311	.....	0-25	YAHY	10	50	2.5	0.5
43112	4311½	0-30	YAHZ	12	60	2.5	0.5
43115	4311⅝	0-40	YAIF	8	40	5.	1.
4312	.....	0-50	YAIG	10	50	5.	1.
43121	4312¼	0-60	YAJA	12	60	5.	1.
43122	4312½	0-75	YAIK	15	75	5.	1.0
43125	4312⅝	0-80	YAIL	8	40	10.	2.
4313	.....	0-100	YAIR	10	50	10.	2.
43131	4313¼	0-120	YAJI	12	60	10.	2.
43135	4313⅝	0-125	YAJO	10	50	12.5	2.5
4314	.....	0-150	YAJU	15	75	10.	2.
43141	4314¼	0-160	YAJZ	8	40	20.	4.
4315	.....	0-200	YAKF	8	40	25.	5.
4316	.....	0-250	YAKI	10	50	25.	5.
4317	.....	0-300	YAKO	12	60	25.	5.
4318	.....	0-400	YAKY	8	40	50.	10.
4319	.....	0-500	YALG	10	50	50.	10.
43192	4319½	0-600	YALI	12	60	50.	10.
4320	.....	0-750	YALJ	15	75	50.	10.
43202	4320½	0-800	YALO	8	40	100.	20.
4321	.....	0-1000	YALU	10	50	100.	20.
43212	4321½	0-1200	YALY	12	60	100.	20.
4322	.....	0-1500	YAMD	15	75	100.	20.
43222	4322½	0-1600	YAMF	8	40	200.	40.
4323	.....	0-2000	YAMH	8	40	250.	50.
43231	4323¼	0-2400	YAME	12	60	200.	40.
43232	4323½	0-2500	YAMI	10	50	250.	50.
4324	.....	0-3000	YAMK	12	60	250.	50.
43242	4324½	0-4000	YAMO	8	40	500.	100.
4325	.....	0-5000	YAMU	10	50	500.	100.
43252	4325½	0-6000	YAMY	12	60	500.	100.
4326	.....	0-7500	YANF	15	75	500.	100.
43262	4326½	0-8000	YANJ	8	40	1000.	200.
4327	.....	0-10000	YANL	10	50	1000.	200.
43272	4327½	0-12000	YANO	12	60	1000.	200.
4328	.....	0-15000	YANU	15	75	1000.	200.
4329	.....	0-20000	YANY	8	40	2500.	500.
4330	.....	0-25000	YAOD	10	50	2500.	500.
43302	4330½	0-30000	YAOJ	12	60	2500.	500.
4349	.....	0-150 NSEW	YAFA	18	90	For Model LR Burton Anemometer	
			CENTER ZERO				
43042	4304½	Blank	YAHE	15	30	.....	.....
4362	.....	2.5-0-2.5	YASN	10	50	0.5	0.1
4331	.....	5-0-5	YAOL	10	50	1.	0.2
4332	.....	10-0-10	YAON	10	50	2.	0.4
43321	4332¼	15-0-15	YAJB	12	60	2.5	0.5
43322	4332½	20-0-20	YAMA	8	40	5.	1.
4361	.....	25-0-25	YASU	10	50	5.	1.
4334	.....	30-0-30	YALD	12	60	5.	1.
43342	4334½	40-0-40	YALE	8	40	10.	2.
4346	.....	50-0-50	YAJD	10	50	10.	2.
4347	.....	60-0-60	YAKC	12	60	10.	2.
4335	.....	75-0-75	YAOP	15	30	10.	5.
4363	.....	80-0-80	YABA	8	40	20.	4.
4333	.....	100-0-100	YAOR	10	50	20.	4.
43362	4336½	125-0-125	YACA	10	50	25.	5.
43352	4335½	150-0-150	YAOW	12	60	25.	5.
4337	.....	200-0-200	YADE	8	40	50.	10.
43331	4333¼	250-0-250	YAOZ	10	50	50.	10.
4343	.....	300-0-300	YAPG	12	60	50.	10.
43432	.....	400-0-400	YAAC	8	40	100.	20.
4344	.....	500-0-500	YAPA	10	50	100.	20.
4340	.....	600-0-600	YADA	12	60	100.	20.
4336	.....	750-0-750	YAPH	15	30	100.	50.
4341	.....	800-0-800	YACE	8	40	200.	40.
4345	.....	1000-0-1000	YAPI	10	50	200.	40.
43452	4345½	1500-0-1500	YAJE	12	60	250.	50.
4350	.....	2000-0-2000	YAKE	8	40	500.	100.
43502	4350½	2500-0-2500	YAEB	10	50	500.	100.
43512	4351½	3000-0-3000	YALA	12	60	500.	100.
4352	.....	4000-0-4000	YANA	8	40	1000.	200.
43521	4352¼	5000-0-5000	YALC	10	50	1000.	200.
43522	4352½	6000-0-6000	YAKA	12	60	1000.	200.
4353	.....	8000-0-8000	YANE	8	40	2000.	400.
43332	4333½	10000-0-10000	YAPK	10	50	2000.	400.

†When ordering, speed designating letter must be added; see page 73.

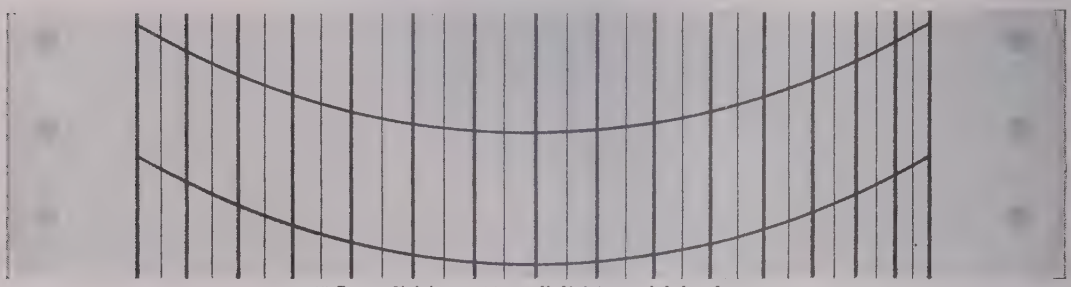
Charts for Model LR, MS and EB Wattmeters and RKVA Meters

(Not for Model AW Recorders)

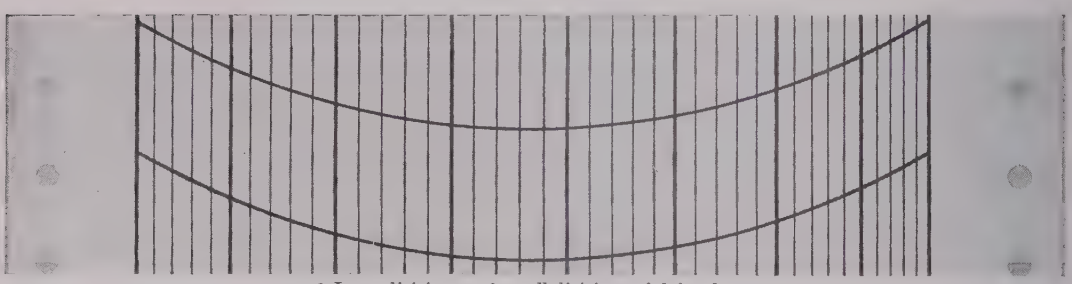
Non-uniform ruling. Charts shown actual size.



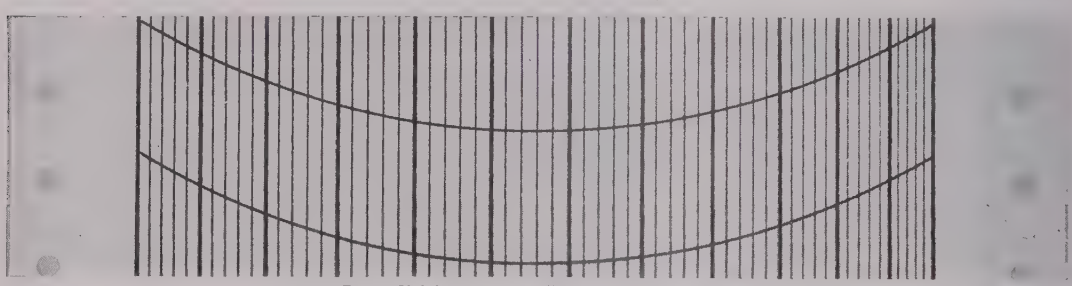
10 Large divisions—50 small divisions—left-hand zero



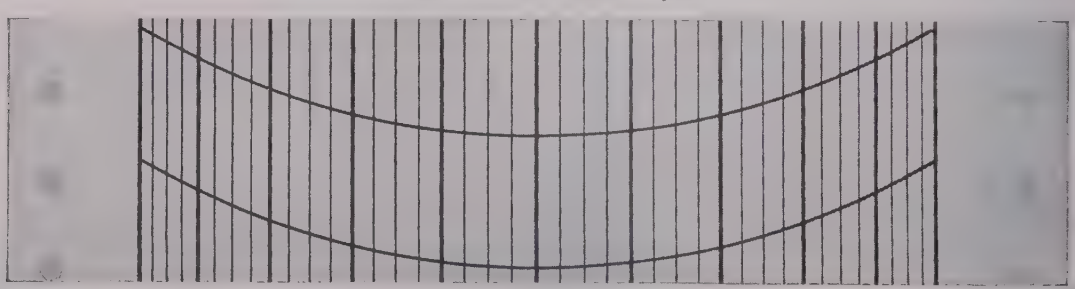
15 Large divisions—30 small divisions—left-hand zero



8 Large divisions—40 small divisions—left-hand zero



12 Large divisions—60 small divisions—left-hand zero



10 Large divisions—40 small divisions—center zero only

Charts for Model LR, MS and EB Wattmeters and RKVA Meters

(Not for Model AW Recorders)

Non-uniform ruling.

Chart Number†	Chart Range	Code Word†	Number Large Divisions	Number Small Divisions	Value One Large Division	Value One Small Division
1000	Blank	WYLL	.....	.....	.....	.....
2301	Blank	WYRI	15	30	.....	.....
2302	Blank	WYRO	10	50	.....	.....
2303	Blank	WYPP	8	40	.....	.....
2304	Blank	WYPS	12	60	.....	.....
2310	0–1	WYRS	10	50	0.1	0.02
2310½	0–2	WYRV	8	40	0.25	0.05
2311	0–2.5	WYSI	10	50	0.25	0.05
2311½	0–3	WYSS	15	30	0.2	0.1
2311⅝	0–4	WYST	8	40	0.5	0.1
2312	0–5	WYSU	10	50	0.5	0.1
2313	0–10	WYSW	10	50	1.	0.2
2314	0–15	WYTU	15	30	1.	0.5
2314½	0–20	WYTV	8	40	2.5	0.5
2315	0–25	WYTY	10	50	2.5	0.5
2315½	0–30	WYUF	15	30	2.	1.
2315⅝	0–40	WYUH	8	40	5.	1.
2316	0–50	WYUJ	10	50	5.	1.
2316½	0–60	WYUP	12	60	5.	1.
2317	0–75	WYUS	15	30	5.	2.5
2317½	0–80	WYUT	8	40	10.	2.
2318	0–100	WYUV	10	50	10.	2.
2318½	0–120	WYUX	12	60	10.	2.
2318⅝	0–125	WYVI	10	50	12.5	2.5
2319	0–150	WYVO	15	30	10.	5.
2319½	0–160	WYVU	8	40	20.	4.
2320	0–200	WYVV	8	40	25.	5.
2320½	0–225	WYVW	15	30	15.	7.5
2321	0–250	WYVZ	10	50	25.	5.
2322	0–300	WYWI	15	30	20.	10.
2322½	0–375	WYWO	15	30	25.	12.5
2323	0–400	WYWU	8	40	50.	10.
2323½	0–450	WYWY	15	30	30.	15.
2324	0–500	WYZI	10	50	50.	10.
2324½	0–600	WYZO	12	60	50.	10.
2325	0–750	WYZU	15	30	50.	25.
2325½	0–800	WYZZ	8	40	100.	20.
2326	0–1000	YAAH	10	50	100.	20.
2326½	0–1200	YAAL	12	60	100.	20.
2327	0–1500	YAAM	15	30	100.	50.
2327½	0–1600	YAAN	8	40	200.	40.
2328	0–2000	YAAR	8	40	250.	50.
2328½	0–2400	YAAS	12	60	200.	40.
2329	0–2500	YAAT	10	50	250.	50.
2330	0–3000	YAAW	15	30	200.	100.
2331	0–4000	YABI	8	40	500.	100.
2332	0–5000	YABO	10	50	500.	100.
2332½	0–6000	YABR	12	60	500.	100.
2333	0–7500	YABV	15	30	500.	250.
2333½	0–8000	YABY	8	40	1000.	200.
2334	0–10000	YACI	10	50	1000.	200.
2334½	0–12000	YACS	12	60	1000.	200.
2335	0–15000	YACU	15	30	1000.	500.
2350	0–100000	YACW	10	50	10000.	2000.

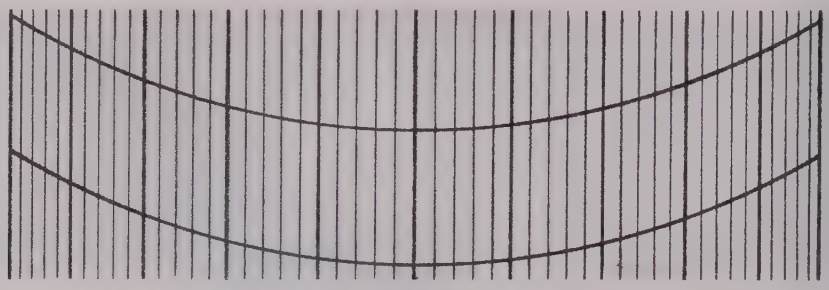
CENTER ZERO

Chart Number†	Chart Range	Code Word†	Number Large Divisions	Number Small Divisions	Value One Large Division	Value One Small Division
2305	Blank	WYPO	10	40	.....	.....
2306	Blank	WYPI	15	30	.....	.....
2307	Blank	WYSA	10	50	.....	.....
2344	15–0–15	YADO	15	30	2.	1.
2342	30–0–30	YADT	15	30	4.	2.
2343	60–0–60	YADU	15	30	8.	4.
2336	100–0–100	YADV	10	40	20.	5.
2346	1200–0–1200	YADY	10	40	240.	60.
2340	3200–0–3200	YAEG	10	40	640.	160.
2337	4000–0–4000	YAEL	10	40	800.	200.
2337½	8000–0–8000	YAEP	10	40	1600.	400.
2338	10000–0–10000	YAEM	10	40	2000.	500.
2353	15000–0–15000	YAER	15	30	2000.	1000.
2354	20000–0–20000	YAEW	10	40	4000.	1000.

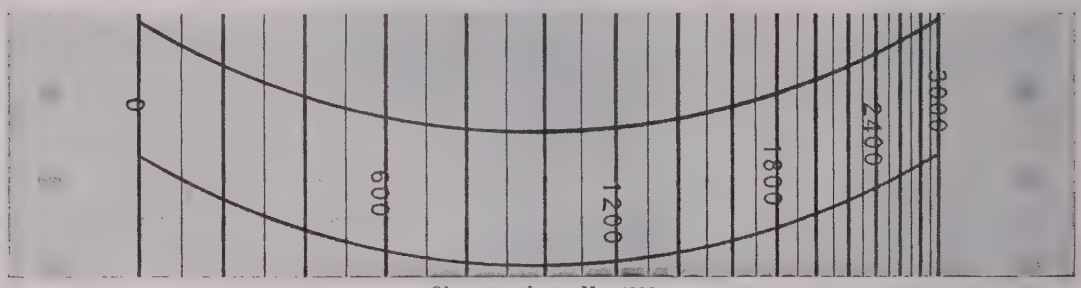
†When ordering, speed designating letter must be added; see page 73.

Charts for Model AW, LR and MS Frequency Meters, Ohmmeters, Conductivity and Operation Recorders

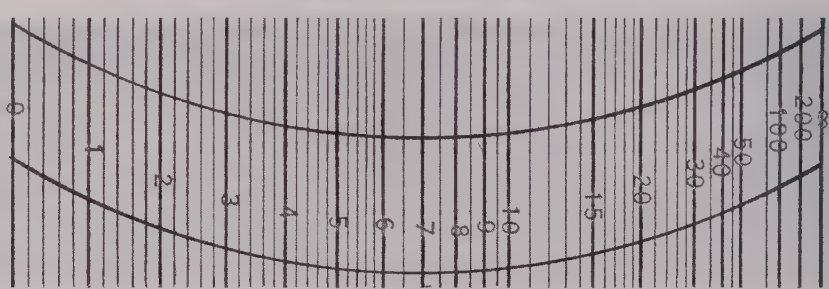
Charts shown actual size.



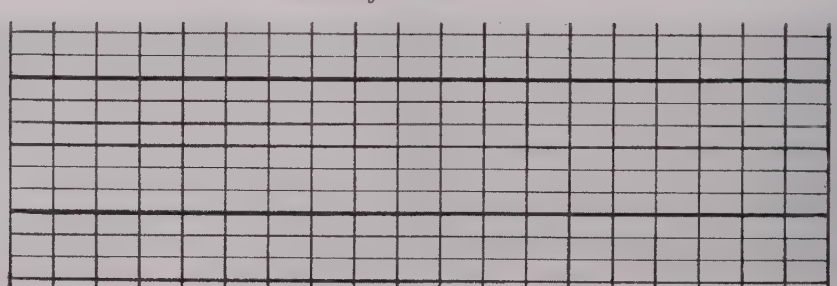
Frequency meter charts



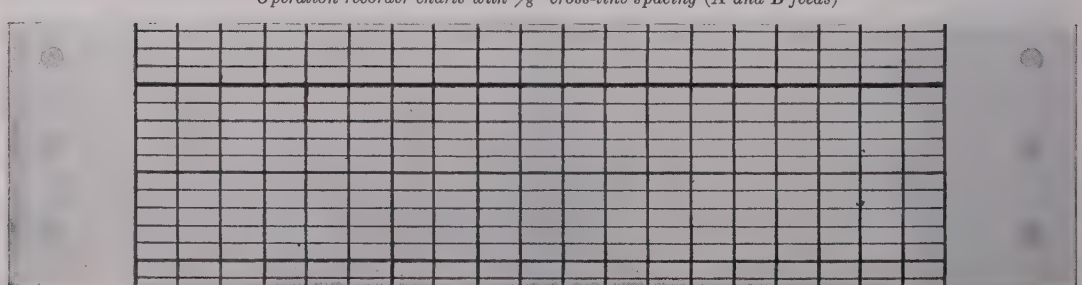
Ohmmeter chart—No. 1600



Conductivity meter chart—No. 1605



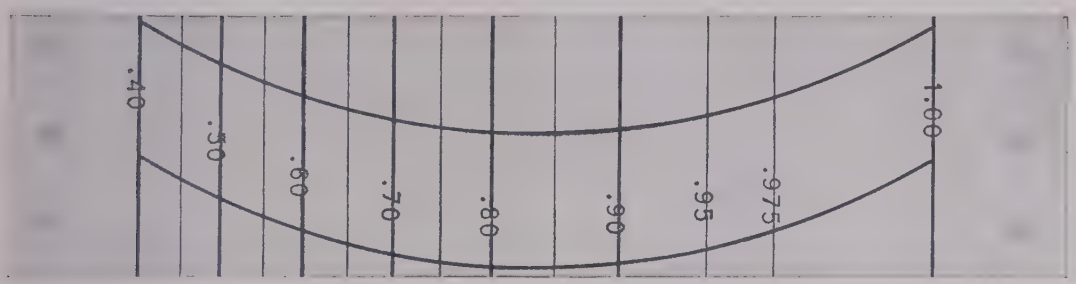
Operation recorder charts with 1/8" cross-line spacing (A and B feeds)



Operation recorder charts with 1/10" cross-line spacing (C, D and E feeds)

Charts for Model AW, LR and MS Frequency Meters, Power Factor Meters, Ohmmeters, Conductivity and Operation Recorders

Power factor chart—No. 1407



Power factor chart—No. 1403

Type of Chart	Chart Number†	Former Chart No.	Chart Range	Code Word†	Number Large Divisions	Number Small Divisions	Value one Large Division	Value one Small Division
Blank	1000	.....	Blank	WYLL	.....	.....	.....	.....
Frequency	1515	.....	55–65 cycles	YARV	10	50	1 cycle	0.2 cycle
Frequency	1550	.....	45–55 cycles	YASE	10	50	1 cycle	0.2 cycle
Frequency	1520	.....	20–30 cycles	YASA	10	50	1 cycle	0.2 cycle
Frequency	1552	.....	45–65 cycles	WYTE	10	40	2 cycles	0.5 cycle
Ohmmeter	1600*	.....	0–3000	YASK	15	30	200	100
Conductivity	1605*	.....	0–infinity	YASL	18	61	.....	.....
Power Factor	1407	.....	.50–1.00–.70	YARM	8	18	.10	.05 and .025
Power Factor	1403	.....	.40–1.00	YARK	6	13	.10	.05 and .025
							TIME RULING	
Operation Recorder	1700	.....	Blank	YARA	20 lines		1/10″ spacing (C. D and E Feeds)	
Operation Recorder	17002	1700½	Blank	YARE	20 lines		1/8″ spacing (A and B Feeds)	
Operation Recorder	1705	.....	1–5	YAPM	20 lines		1/8″, A and B Feeds; 1/10″, C, D and E Feeds	
Operation Recorder	1710	.....	1–10	YAPO	20 lines		1/8″, A and B Feeds; 1/10″, C, D and E Feeds	
Operation Recorder	1720	.....	1–20	YAPU	20 lines		1/8″, A and B Feeds; 1/10″, C, D and E Feeds	
Operation Recorder	1740	.....	21–40	YARI	20 lines		1/8″, A and B Feeds; 1/10″, C, D and E Feeds	
Operation Recorder	1760	.....	41–60	YARJ	20 lines		1/8″, A and B Feeds; 1/10″, C, D and E Feeds	

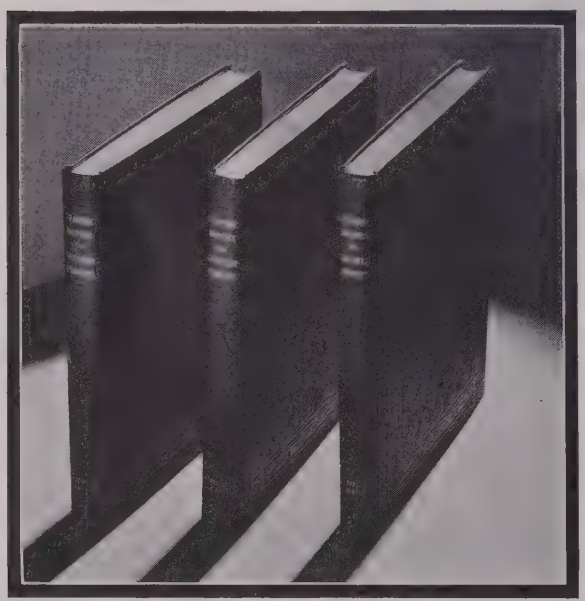
Operation recorder charts in X feed are regularly furnished with 1/10″ time ruling, the same as No. 1700 listed above. Such charts are designated 1700-X, 1705-X, 1710-X, 1720-X and 1740-X. Charts with 1/8″ ruling, such as No. 17002 listed above, can be furnished in minimum quantities of 24; such charts are designated 17002X, 17052X, 17102X, 17202X and 17402X.

*Stocked only in B-feed (1½-inch per hour).

†When ordering, speed designating letter must be added; see page 73.

A Reference Book on the Use of Graphic Instruments

● The value of a graphic instrument lies in its ability to secure facts upon which engineers and executives can base their work. Realizing the need for something which would show just how graphic instruments can be applied to specific problems and just what results they can secure, the Esterline-Angus Company has gathered together a quarter of a century's experience and condensed it into a single volume. This volume is devoted solely to graphic meter accomplishments; it does not discuss details of their construction or operation.



This reference work enables the practical engineer and the busy executive to use graphic instruments most effectively. Its "case histories" embody the hard-won experience of the country's most alert and skillful men, working in every conceivable kind of plant and industry. These cases are presented with particular accent on economic aspects, and appeal to the manager as well as the technician.

"Graphic Routes to Greater Profits" contains 320 pages, 8–1/2 by 11 inches. There are 19 chapters, grouped in 7 sections. Each chapter contains an introductory discussion of the "philosophy" of the problem which that chapter treats. There are 456 illustrations, 17 being full pages. There are 278 separate, complete, and detailed examples, presented in 239 episodes. These are elaborately cross-indexed. The book has a lifetime binding of grained and tooled Fabrikoid.

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"Graphic Routes to Greater Profits" is unique in the field of technical literature and presents an entirely new concept of instrumentation as an industrial tool. To anyone facing problems of machines, processes, products or men, it truly points the way to higher efficiency and greater profits.

This reference book is $2.00 postpaid and may be returned after ten day inspection if purchaser is not satisfied.

Field Engineers

● This company earnestly desires that every piece of equipment we sell shall accomplish the purpose for which it was purchased. To this end there are located in the industrial centers listed below, field engineers who understand our instruments and their correct application to a wide variety of technical, industrial, scientific and research problems. Their services are available without obligation.

Information regarding price and delivery on charts, ink, pens, inking tools, etc., will be found on the back cover of this catalog. Further data on any of these, as well as information on other items described in this catalog, will be gladly supplied by your local field engineer or by the factory in Indianapolis. However, we suggest contacting the field engineer inasmuch as he will quote the same prices which we quote from the factory, and he is qualified to give assistance on any problems involving the use of our product.

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PRICE LIST

EFFECTIVE SEPT. 1, 1947

The prices of some commonly ordered supplies and parts for Esterline-Angus Graphic Instruments are as follows:

		NET PRICE EACH
FOR ALL MODELS	Record Charts (printed), lots of 1-23	$1.50
	" " " " " 24-47	1.35
	" " " " " 48-95	1.20
	" " " " " 96-249	1.05
	" " " " " 250-499	.90
	" " " " " 500-999	.80
	" " " " " 1000-1999	.72
	" " " " " 2000 or over	.68
	Ink, red or green, 2 oz. bottles, lots of 1-9	.75
	Ink, red or green, 2-oz. bottles, lots of 10 or more	.60
	Ink, red or green, pint bottles, lots of 1-9	2.50
	Ink, red or green, pint bottles, lots of 10 or more	2.25
	Glass pen points, Code WYBUG, lots of 1-9	.75
	Glass pen points, Code WYBUG, lots of 10 or more	.60
	Pen Filler, duckbill type, Code WYJIL	.75
	Inkwell Filler (ink dropper), CODE WYJJA	.25
	Accessory Kit "AW"; (glass pen point, 2-oz. bottle of red ink, inkwell filler and pen filler all in round cardboard container), Code ZEMHO	2.50 ~~2.25~~
	Clock oil, small bottle, Code WYCIF	1.00
	*Standard pen element, for all meters except operation (time) recorders	3.00
	*Operation (time) recorder pen element	2.50
	*Standard inkwell for all model AW and LR, except operation (time) recorders	3.00
	*Scaleplate with standard range	3.00
	*Current lead, 5 feet long, No. 4 wire (for DC or utility wattmeters)	3.00
	*Current lead, 5 feet long, No. 8 or No. 10 wire	2.50
	*Potential lead, 5 feet long, No. 14 wire	1.50
	*Change gears, per pair	1.50
	*Brushes for external DC motor, per pair	.30
	*Brush and spring assembly for tachometer generator	4.00
	*Instruction book	No charge
FOR MODEL AW ONLY	Clock winding crank, No. 8290, Code WYEIK	.75
	Lamp for flush meter, 115-volt, 15-watt, Code WYBOF	.50
	Lamp for flush meter, 230-volt, 15-watt, Code YIDEG	.75
	*Chronograph pen element with inkwell	~~4.50~~ 5.00
FOR MODELS LR, MS & EB ONLY	Clock key, No. 3970, Code WYDOH	.25
	Damper oil, 4-oz. bottle, Code WYAXY	.75
	Damper oil, pint bottle, Code WYBBA	1.50
	Ink pump with rubber tube, Code WYDFE	.50
	Oil pump, Code WYDHO	.50

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